PROCEEDINGS

OF

THE 33RD NATIONAL CONFERENCE AND ANNUAL GENERAL MEETING

OF THE

Nigerian Institution of Agricultural Engineers

(A Division of Nigerian Society of Engineers)

ENGINEERING THE AGRICULTURAL TRANSFORMATION AGENDA

Volume 33, 2012
November 5th– 9th, 2012

Wikki Spring 2012

PROCEEDINGS

OF

THE 33RD NATIONAL CONFERENCE AND ANNUAL GENERAL MEETING (WIKKI SPRING 2012)

OF THE

NIGERIAN INSTITUTION OF AGRICULTURAL ENGINEERS

THEME:
ENGINEERING THE AGRICULTURAL TRANSFORMATION AGENDA

SUB-THEMES:

- Mechanizing Agriculture for Import Substitution and Food Security
- Managing Natural Resources for Sustainable Development
- Value Addition of Agricultural Products for Economic Empowerment
- Energy Resources and Infrastructure for Employment Generation
- Emerging Technologies for Agricultural Transformation
- Climate Change and Environmental Management for Sustainability
- Policy, Legal and Institutional Framework in Engineering for Agricultural Transformation

VENUE: M.L. AUDU MULTIPURPOSE AUDITORIUM
THE FEDERAL POLYTECHNIC, BAUCHI, BAUCHI STATE

DATE: NOVEMBER 5 – 9, 2012

PROC, NIAE: VOLUME 33, 2012
© NIAE, 2012

ISSN: 0794 - 8387

PREFACE

The theme for WIKKI SPRING 2012 is structured to fit into the current national transformation agendaof the Federal Government. Just like all other sectors of the Nigerian economy, the nation's agriculture is in the process of strategicdevelopment,and Agricultural Engineers have pivotal roles to play in this transformation. The focus of this conference is thereforeto pool AgriculturalEngineers and other related experts from within and outside Nigeria to deliberateand articulate the various ways in which AgriculturalEngineers could positively contribute in the realisation of the agricultural transformation agenda. The nation isat present saddled with environmental challenges such as desertification in the north and flooding in some central and southern parts of the country. It is in recognition of this, that two of the conference sub-themes:

- Managing Natural Resources for Sustainable Development
- Climate Change and Environmental Management for Sustainability were carved out to addressthe aforementioned problems.

Our roles asAgriculturalEngineers is rapidly evolving from traditionalemphasis on increasing productivity and reducing drudgery given increasing needs for research and adoption of best practices in the production of biologically based goods in addition to the management and protection of natural resources.

We invited articles from core AgriculturalEngineers and other related experts through circulation of the conference flyers. The articles were subjected to peer review by seasoned AgriculturalEngineers. This book of proceedings is the outcome of the review process. It is our expectation that participants would be professionally enriched by this compilation and indeed by all the presentations during the conference. We equally hope that the outcomes of the deliberations would bring to the fore specific ways in which we could contribute positively in transforming the nation's agricultural sector for improved performance and sustainability.

We express our profound gratitude to all the authors, reviewers and organisers of this conference (WIKKI SPRING, 2012) who, despite the many challenges have made this conference successful.

Dr. MOFOKE, A. L. E.
Chairman, Technical Sub-Committee
WIKKI SPRING 2012

LOC MISSION STATEMENT

The ***THEME***for this year's conference tagged **'WIKKI SPRING 2012' is *ENGINEERING THE AGRICULTURAL TRANSFORMATION AGENDA.***

Transformation can be defined as a complete change, usually into something with an improved usefulness. The transformation agenda is therefore a vision accompanied with mission statement that will transform the Nigerian nation for better in the nearest future.

The Transformation Agenda is borne out of Mr. President's passion for the country that if we must become one of the foremost celebrated nations; we cannot afford to do things as 'usual'. There is therefore the need for a complete change in the way things are done in Nigeria. The transformation agenda is not now that of Mr. President and his ministers alone. It has become the National transformation agenda because of its wide acceptability.

Agricultural Transformation Agenda (ATA) which seeks to:

- Secure food and feed needs of the nation
- Enhance generation of National and Social wealth through greater export and import substitution
- Enhance capacity for value addition leading to industrialization and employment opportunities
- Explore efficient utilization of available agricultural resources.
- Enhance the development and dissemination of appropriate and efficient technologies for rapid adoption
-

is an important component of the Transformation Agenda. The theme of this conference is an indication that **The INSTITUTION OF AGRICULTURAL ENGINEERS** have completely bought into this agenda and are ready to make all the necessary contributions towards its success.

Agricultural Transformation Agenda (ATA) is task that must be done but it must be ENGINEERED for a complete such. Therefore it is very important to bring together these eminent engineers to contribute their quotas through delivery of scholarly papers on this subject matter. It is my sincere hope that through this conference the nation Nigeria will make a very big stride in the positive direction in reaching our goal of the Agricultural Transformation Agenda and then the Transformation Agenda in general such that our investment into this noble course will not be a waste.

Samuel Sule, Ph.D, MNIAE, MNSE, COREN Reg.
LOC Chairman

NATIONAL EXECUTIVE COUNCIL

THE NIGERIAN INSTITUTION OF AGRICULTURAL ENGINEERS

Engr. Prof. S. Z. Abubakar	Chairman
Engr. Prof. B. A. Adewumi	Vice Chairman
Engr. Dr. M. K. Othman	National Secretary
Engr. J. C. Adama	Asst. National Secretary
Engr. Dr. J. O. Olaoye	National Financial Secretary
Engr. (Mrs) C. A. Adamade	National Treasurer
Engr. Dr. G. I. Nwadikom	Publication Secretary
Engr. Dr. M. A. Enabiofor	National Publicity Secretary
Engr. Dr. S. M. Musa	Ex-Officio
Engr. (Mrs) Nwagugu	Ex-Officio
Engr. Prof. A. P. Onwualu	Editor in Chief
Regional Chairmen	
Engr. A. A. Akintola	North Central
Engr. Dr. Shehu Adamu Isa	North East
Engr. J. O. Daudu	North West
Engr. E. Clinton	South East
Engr Dr. L. A. O. Ogunjimi	South West
Engr. A. L. Ijasan	South South
Co-opted Members	
Engr. Ike Azogu	Executive Director, NCAM
Engr. M. Y. Kasali	Business Manager

CENTRAL LOCAL ORGANISING COMMITTEE (Central LOC)

Engr. Dr. Samuel Sule (FPTB)	Chairman
Engr. Prof. H. Muhammad (ATBU)	Member
Engr. Dr. S. M. Musa (FPTB)	Member
Engr. Dr. A. L. E. Mofoke (ATBU)	Member
Engr. Clement Ezeaku (FPTB)	Member
Engr. Yohanna D. Ali (FPTB)	Member
Engr. Cyprain N. Ohanwe (FPTB)	Member
Engr. Ahmed Usman Ibrahim (ATBU)	Member
Engr. Bala Gambo Jahun (ATBU)	Secretary

SUB-COMMITTEES

TECHNICAL SUB-COMMITTEE

Engr. Dr. A. L. E. Mofoke (ATBU)	Chairman
Engr. Dr. L. G. Abubakar (ATBU)	Member
Engr. Clement Ezeaku (FPTB)	Member
Engr. Dr. Samuel Sule (FPTB)	Member
Engr. O. L. Akangbe (ATBU)	Secretary

FUND RAISING SUB-COMMITTEE

Engr. Dr. S. M. Musa (FPTB)	Chairman
Engr. Prof. H. Muhammad (ATBU)	Member
Engr. Muh'D Dhamina (Hon. Com. Min. for Info)	Member
Engr. Muh'D Sani Ibrahim (MANR)	Member
Engr. Dr. Samuel Sule (FPTB)	Member
Engr. Bala Gambo Jahun (ATBU	Secretary

WELFARE SUB-COMMITTEE

Engr. Ahmed Usman Ibrahim (ATBU)	Chairman
Engr. Hassan Saeed (ATBU)	Member
Engr. (Mrs) Nafisatu Abdulhamid (ATBU)	Member
Engr. Victoria Abodienyi (FPTB)	Member
Engr. Tom Itodo (FPTB)	Member
Engr. Ahmed Abubakar (ATAP)	Secretary

ACCOMMODATION SUB-COMMITTEE

Engr. Dr. L. G. Abubakar (ATBU)	Chairman
Engr. Sunday Atanu (FPTB)	Member
Engr. Cyparian N. Ohanwe (FPTB)	Member
Engr. David Joshua Zwull (MANR)	Member
Engr. Lagasi Joseph (FPTB)	Member

TRANSPORTATION/EXCURSION SUB-COMMITTEE

Engr. Clement Ezeaku (FPTB)	Chairman
Engr. Alabi Abdul Ganiyu (FPTB)	Member
Engr. Saleh Yakmud (FPTB)	Member
Engr. Saidu Muh'D (MANR)	Member

EXHIBITION SUB-COMMITTEE

Engr. Cyprain N. Ohanwe (FPTB)	Chairman
Engr. Saleh yakmud (FPTB)	Member
Engr. Sunday Atanu (FPTB)	Member
Engr. Victoria Abodienyi (FPTB)	Member
Engr. Aminu Muh'D (ATAP)	Member

WIKKI SPRING 2012 EDITORIAL BOARD

1) Dr. S. M. Musa
2) Dr. Sule Samuel
3) Dr. Shehu A. Iya
4) Dr. Mofoke A. L. E
5) Dr. M. A. Ali
6) Dr. L. G. Abubakar
7) Prof. Z. D. Osunde
8) Dr. (Mrs) Bolanle Adenike Adejumo
9) Dr Folarin Alonge
10) Dr M. K. Othman
11) Engr. O. L. Akangbe
12) Engr. A. U. Ibrahim
13) Dr. Fati A. Atipawa
14) Dr. T. S. Kwayas
15) Engr. Clement Ezeaku
16) Engr. Cyprian Ohanwe
17) Engr. B. G. Jahun
18) Engr. Oiganji Ezekiel
19) Engr. Habib. A. Imam
20) Engr. Sarafadeen Shittu
21) Engr. Afolabi Akintayo
22) Engr. Mac Ndukwu
23) Engr. Joseph Adama

\

Alhaji (Dr) Aminu Saleh, CFR, GCON
Wamban Katagum
P.O.Box 153, Emir's Palace Drive, Azare
November, 2012

NIGERIAN INSTITUTION OF AGRICULTURAL ENGINEERS (NIAE) 33RD NATIONAL CONFERENCE AND ANNUAL GENERAL MEETING, BAUCHI 2012

All protocols observed

ENGINEERING THE AGRICULTURAL TRANSFORMATION AGENDA OPENING REMARKS BY CHAIRMAN OF THE OCCASION

Alh. (Dr) Aminu Saleh, CFR, GCON,
Wamban Katagum

I have accepted your invitation to be the Chairman of this occasion, when at the same time I am asked to submit an opinion paper on general overview of the theme and sub-themes of the conference. My opening remarks will just be a few words of encouragement and confidence boosting as I am delighted with your strong sense of mission in this historic sacrifice. This effort of your institution will remain a lesson in the national service which professional associations ought to emulate in the overall interest of our fatherland. You have to continue to cultivate the relevant qualities to sustain this unique challenge of transformation of agriculture, by maintaining fairly good tempo of activities. Our people are eagerly awaiting, are full of expectation and have high hopes for improvement in quality of life. I am confident that you are up to this daunting task. I guess my opinion paper is for plenary session.

I will like to recall that my boss and role model Dr. Pius Okigbo was once forecasting that the outcome of the European, Chinese etc advances in technology in agriculture "is to increase the technological dependence of Africa in the area of food security, on the West". Sir, this is now the unfortunate situation in Nigeria, **since we spent N1.3tr on rice, wheat, sugar, fish importation in 2010,** things that could be produced locally. Distinguished participants, our hope is in S and T planning, it is like a dream with your eyes wide open. I want to ask you about the likely changes you are fore sighting for the future if you really want to emphasis S&T in your recommendations? Fore sighting in science and technology is not the same as the conventional forecasting. Proponents of fore sighting advise that S and T planers should ask hard questions and think the unthinkable (even like fairy tales) and then plan and hope for technological advances to provide solutions. I will take advantage of this opportunity to state the following 5 attributes that are among 10 listed devices (I hold the remaining 5 to myself) used to encourage a planer to think about how things could be different or better (1) **adaptation:** what else is like it? What other ideas does it suggest? What could you copy? What could you imitate? (2) **modification:** what new twist could be made? Can you change the color, size, shape, motion, sound, form, or odor? (3) **minification:** can you make it smaller, shorter, lighter, or lower? Can you divide it up or omit certain parts? (4) **rearrangement:** can you interchange parts? Can you use a different plan,

pattern, or sequence? Can you change the schedule or rearrange cause and effect? (5) **reversibility:** can you turn backward or upside down? Can you reverse roles or do the opposite? Once upon a time U.S.A. declared vocational education for youth a top priority because they wanted to win the race for technical competence and superiority, can we copy this?

In Europe, China, India, etc their method of farming is more scientific therefore more productive. In those countries, mechanization brought about considerable progress in output with explosive growth in the use of agricultural chemicals, herbicides, insecticides, fungicides, and fertilizers (with their hazards). They also develop high yielding species that lead to intensive farming on the land with sufficient rearing of cattle and poultry production. They went further into genetic engineering method for hybridization and embark on pest control by use of chemicals.

In Nigeria, we are still at the primitive level making use of natural element of climate such as rainfall, sunshine and soil condition. Every farm work is done manually from land preparation, plowing, cultivating, harrowing, to seed planting and tree planting, harvesting, processing, and storage. We have no knowledge of, and therefore don't monitor acidity or nutrients, nothing protects the shallow soil, in our area the rainfall is not enough to saturate the soil for more than two months. Even the use of simple machine and implement in place of manual labor or the use of animals on the farm is not there productivity per man per acre is low. Again, there are no machines available to help people in the homes for domestic activities. With all the money spent these years on research and development in Agriculture very little has changed. I will like to recall an American question: "***is gov't dead?" this was what TIME MAGAZINE of New York asked in 1980. The question was asked because school standards had gone low, hospital care was nil, courts were over crowded and most of the city councils were bankrupt, confidence in gov't had fallen to record low, cities and high ways succumb to mounting crimes*** *end of quote.*

Therefore, we are putting a lot of hope on this program. Distinguished participants, I come from an area where scarcity of drinking water is another problem for the inhabitants. There is very little groundwater recharge at the upper aquifer due to lack of rainfall (vagaries of nature) not to talk of the recharge at the larger aquifer below. However, the situation is completely different at Nguru wetlands with incessant flooding and stagnation where conveyances are not desalted and cleared, ambient condition for **TYPHERGRASS** (**Kachalla**). Please consider under climate change that the rains fall in a short period, can be very intensive resulting in large volume of flows, which is all lost there is the need for inter basin water transfer and construction of large dams with hydropower that are more cost effective in terms of cost per unit volume of water impounded, under **national management of rain water use and control.** Sir, for a start, how do we undertake research into discovering cheap method of distilling ground water reservoirs or where a surface water deposit forms in poorly drained area? Potable water supply and good sanitation for about 80% of our population was promised by the gov't, but alas we are yet to see it happen.

Another important issue is the impact of rural-urban drift that must be part of your recommendations. It is caused by lack of basic modern amenities in the rural areas, that in itself drives youth prematurely away from rural family homes. Due to lack of job opportunities, youth are unable to practice vocation or embark upon economic activities in their rural communities. If your conference is to provide inputs for the preparation of plans, be they long term, medium term or short term, you have to take a second look at the agricultural objectives, goals, targets, strategies and action plans, to ensure their clarity, consistency, realism, feasibility and challenges, particularly change from rainfed to irrigation farming, to achieve national aspirations. Where to begin your transformation is to focus on sensitization through mass mobilization and support

building to spread the message to the public and policy makers. Crafting a befitting program is one thing, implementation is another. You have to take further stride to achieve your goals.

You, as professionals in this field, understand better than others, what needs to be done to move the sector forward. Given the reality of the situation on the ground, one can see little sense in embarking on projects with little economic advantage like Millennium building against sensible agricultural development, this is a proof of inability to distinguish between (1) **vital national policy** which if not attended to will create direct adverse consequences on national interest (2) **critical national interest** (3) **peripheral national interest**, which if not attended to will threaten vital national interest. I know we can not take up all these interests at the same time, but we have to make the best choices.

Thank you for listening and God Bless.

Alh. (Dr) Aminu Saleh, CFR, GCON
Wamban Katagum

NIGERIAN INSTITUTION OF AGRICULTURAL ENGINEERS (NIAE)

33RD NATIONAL CONFERENCE AND ANNUAL GENERAL MEETING, BAUCHI 2012

ENGINEERING THE AGRICULTURAL TRANSFORMATION AGENDA

AN OPINION PAPER PRESENTED

BY

Alhaji (Dr) Aminu Saleh, **CFR, GCON**

WAMBAN KATAGUM

P.O.BOX 153, EMIR'S PALACE DRIVE, AZARE

NOVEMBER, 2012

Alhaji (Dr) Aminu Saleh, **CFR, GCON**
Wamban Katagum
P.O.Box 153, Emir's Palace Drive, Azare
November, 2012

NIGERIAN INSTITUTION OF AGRICULTURAL ENGINEERS (NIAE) 33RD NATIONAL CONFERENCE AND ANNUAL GENERAL MEETING, BAUCHI 2012

All protocol observed

ENGINEERING THE AGRICULTURAL TRANSFORMATION AGENDA

AN OPINION PAPER PRESENTEDBY THE CHAIRMAN OF THE OCCASION

Alh. (Dr) Aminu Saleh, **CFR, GCON,**

Wamban Katagum

It gave me great pleasure when I visualized the prospects for the future through the Theme and the Sub-Themes of the proposed conference for the exchange of ideas and experiences on appropriate technology for engineering the agricultural transformation agenda. I am highly encouraged to see the broad base list of people and organizations from whom you expect paper presentations. It is only people with spirit of nationalism and patriotism that can agree to start the effort of reviewing and improving our economic position after realizing how slow our march forward has been, this is being done now before it is too late, by that time we will be forced to do it by an unexpected financial circumstances, under the condition of necessity is the mother of invention. There is an advice from Abubakar Gimba to whoever embarks on such exercise, he said in his book **Letter to the unborn child** that "courage, guts, perseverance and prayers are the very essential provision you must have for the daunting journey of transformation of our nation. **Courage** to dare to even start, **guts** to face the challenges along the route, **perseverance** in the pains and sacrifices occasioned by the struggles the journey entails, and **prayers** for providential support". We need people like you with great capacity for persistence, sacrifice and suffering to pursue this effort. I hope yours will be a move to the restoration of hope.

The verbal noun engineering is formed from the word engine. Engine is defined as something used to produce motion, engineering is therefore not limited to those students of physics alone, it must include people who produce motion in any other endeavors. For example, there are courses of MSc and PhD program available in qualitative finance, financial mathematics called FINANCIAL ENGINEERING in many universities abroad. This is a new technique used in developing management to a high standard of efficiency by those who provide services in areas such as financial risk assessment, valuation of physical assets and risk management solutions.

Many of us became worried when we read in the Newspapers reports of (1) looming food crises (2) desertification: Northern Nigeria's most pressing environmental problem (3) **Nigeria spent N1.3tr on rice, wheat, sugar, fish importation in 2010,** things that could be produced locally etc. it pains to hear that other countries are progressing economically while Nigeria is not

doing enough. I hope your conference will attempt to answer the relevant question of how do we leverage science and technology to be a platform for our rapid transformation of all sectors, in particular, the agricultural and commodity based activities that must be propelled.

S and T play a fundamental role in wealth creation, improvement of quality of life, real economic growth and transformation in any country. China now produces enough food to feed its over one and a half billion people and has enough left over to export, but it has only 6% of the world's arable land. China now feeds 22% of world's population. We must admit, right from the beginning of our discourse that, although complete economic evolution is slow and arduous yet our economic progress is at stand still. It was, once upon a time, expected that by now, we should be able to feed ourselves and as a result our poverty level would have declined and our wealth creation efforts would have been expanded. Nothing like that has happened. This means that in Nigeria WE CAN TALK ABOUT EVERY THING AND DO SOMETHING ABOUT NOTHING. I take your conference to be a good starting point in the right direction. **We can't all be China** but we must attempt to improve our economic performance. IT IS BETTER LATE THEN NEVER. But I believe the guilt of not doing anything for Nigeria is a nemesis which will catch up with those responsible for not doing anything.

Background Nigeria is well endowed with natural and human resources. If we, Nigerians, create the enabling environment, we can exploit these resources and make our country an industrial nation and Africa's leading economy. We can achieve and sustain the fastest economic growth rate in Africa with the highest ratio of manufacturing to GDP, the highest level of foreign reserves, with the strongest currency and the highest quality of life on the continent. The challenges in the above sentence are to increase the ability of Nigerians to compete with people of another nations, to make Nigeria the most preferred nation for all Nigerians. We can do this by devising and implementing policies which build on Nigeria's strengths and potentials to achieve such aspirations. Nigerians have to be nation builders and you as professional people should produce superior solutions. Our size and location made Nigeria the shopping centre of most surrounding, near and far, countries. We can not afford, even if we seem helpless in our own chaotic situation or appear weak, to be indifferent, we have to prevent Nigeria being an economic wasteland.

I know, because I was involved, tens of Nigeria's most able academicians, politicians, business tycoons and technocrats that prepared our development programs, they deserve our respect and sympathy, but from the look of it, nothing is done about their submissions, definitely they could not have a more frustrating assignment. This is because Nigerians always waste creative potentials in second guessing that an inherited program is not a perfect one, and therefore everything must be started a fresh, each one of us is just making a foundation, as such, we can't complete building a house. We must begin by shedding our illusion that whatever our predecessors did is wrong, we should remember that people worked out our development programs perfectly well with those additional issues of international and local interventions, like the **MDGs, NEEDS, SEEDS, LEEPS, PPP, GENDER, ICT,** seven point agenda and the national and state development programs. So the question to ask is why are projects discarded or cancelled without any sound reasons but just on the whims and caprices of an individual? We must put aside parochial personal interest and let the welfare of all people rather than the advantage of a few, to be paramount in our minds.

I was a member of the vision 2010 committee. We said in our final report that "the structure of the Nigerian economy remains unchanged. The economy is still monocultural, the primary product now being crude oil (instead of agricultural produce as it was in the 60s and 70s). Production activities are still highly dependent on imports, as e.g. imported consumer goods, as a proportion of the total imports, remain high at over 30 percent". "Agriculture that offers employment to over 65% of the working population, that account for over 70% of non-oil exports, contributes about 30% of the GDP". No doubt, Nigeria is depending entirely on Crude oil, nevertheless, **less than one half of one percent of the population can be said to be directly engaged in crude oil production. So, we are in a dilemma, thus, the activity that generates the bulk of our financial resources does not employ our people,** so there is no impact on the extension of our technological horizon, if this situation remains like that there will be no self reliance economic growth. Enough for now. Ladies and gentlemen, I have some historical events to narrate, bearing in mind that facts are stubborn things.

It is almost 40 year ago, 1973, that I was covering the assignment of the Federal Permanent Secretary, Federal Ministry of Agriculture. I was incharge of all agricultural research councils, as well as the extension field workers of River Basin Development Authorities at the federal level and was relating closely with International Institute of Tropical Agriculture (IITA), West African rice research council, the FAO and was collaborating well with a host of donor countries for agricultural promotion, every body was contributing his quota judiciously I was in the middle of it. After this long period of time, I noticed that the hopes and wishes for agriculture being pronounced now are virtually similar to those expressed four decades ago. This means that there is no noticeable progress in the sector. Is the sector not accepting improvement or change? This time we have to have sense of purpose, to accept dramatic change. Change is inevitable. As such, we should endeavor to shift from resisting change into accepting and embracing change, as almost every facet of life has been affected by recent and potential advances in technology e.g. in agriculture there is genetic recombination technology for efficient crop breeding.

It is almost 20 year ago, 1993, when I was the Federal Minister of Industries in charge of, among others, Raw Material Research Council that was undertaking research into local raw materials mainly in the agricultural and mining sectors. Attention was paid to raw materials development, industrial research and technology acquisition, adaptation and development, standards and quality assurance etc. I was associating very well with National Economic Reconstruction Fund (NERFUND) set up to finance manufacturing projects that had high level local raw materials contents. UNIDO was organizing for local venture promoters, workshops to train them in knowledge upgrade through formal training in feasibility analysis and reporting, in order to help them achieve economic and financial effectiveness in their businesses. At higher levels we organized for the venture promoters attachment for knowledge imbibitions and technology transfer. Once RMRDC noted with concern that "our indigenous technologists and local fabricators have been largely ignored, with little or no patronage, thus the linkage between industry and the network of engineering institutions and fabricators is almost absent", their contributions have received very little attention. Our industries were then mostly in the hands of expatriates, as if we were still in the old order (colonialism) so the urge to want to develop Nigeria was not with them. Things have since changed, ownership of most of the industries are now by Nigerians, so the circle is complete, therefore, local industrial activities should pick up with local raw materials.

I knew, when I was Federal Minister of Finance, that venture finances were equally available to those not insulated from a general economic turbulence. NERFUND was setup to, among other things, stimulate the rapid rise of SMEs to be real production enterprises in the country. Small and medium scale enterprises, were encouraged by banks through NERFUND to go into production thereby competing with international concerns for attention in the market.

When I was Secretary to the Government of the Federation, SGF, we had many meetings with Economic Summit Group mainly on boosting internal economic activities, in particular, agricultural sector that employed about 80% of the rural people, the productivity per man per acre was very low. We noticed that the overall role of agriculture and agro-allied industries, which were, primarily, to provide food and industrial raw materials had not been fulfilled over the years. Private sector had to be further stimulated as the role of government, it was agreed, was still essentially promotional, even then government incentives were not benefiting the target groups.

Now, after narrating the above historical happenings, you will agree with me that a kind of not knowing what to do or say must have cropped in me somehow, because one could see and agree that there is the syndrome of not doing anything for ourselves, I therefore repeat WE CAN TALK ABOUT EVERY THING AND DO SOMETHING ABOUT NOTHING. My recognition of these weaknesses do not mean that I have given up or lost hope in the quest for progress. The fact is that here we were with financial and developmental structures for any developmental actions, be that by the public or private sector, but nothing had happened for the country to move forward. During my time, in Industry, there were no complaints that the then legislations were not operational nor were any bureaucratic bottlenecks identified that could tend to slow down progress. I remember, towards progressive effort, RMRDC was then talking about "harnessing of abundant agricultural, solid minerals and human resources, that if appropriate and adaptable technologies were used, that could bring about the desired industrialization of the country".

Research and development go hand in hand. The objective of research institute is to produce applied research results that will be adopted by interested entrepreneurs who will work them into viable enterprises. They, both, researcher and developer, must appreciate this relationship. To reach our goals, I will tolerate intellectual property infringement. I will like to quote what Dr. Emmanuel O. Egbogah, said on this, about Nigeria, after he realized that we have technological power vacuum which must be filled in order to mobilize our people. It was reported in Petroleum Technology Development Journal of January, 2012, Vol.2 No.1

> "The future of Nigeria may also lie in **technopreneurship.** Technopreneurs are naturally gifted, smart, creative, but not necessarily formally educated, aggressive young men and women passionate for success, mostly assemblers and at times innovators, and they can be found in most commercial cities in Nigeria. Nigerian technopreneurs should be empowered to thrive for their good, for our good and for the good of the entire economy"

Lack of government attention on **FUNCTIONAL EDUCATIONAL** was a big set back. It could have created the necessary pool of artisans, craftsmen, technicians, technologists and managers. Regrettably, we cant reverse the past, but even the crafts schools and technical colleges established in the early 60s began to fizzle out and died with the introduction of the 6-3-3-4 system of education 1995 which was also detrimental to the youth who lost out in the vocational content and had only futures in academics, enough of this.

Part of the promotion of activities in the non-oil sector and SMEs was the challenge, to the gov't and the private sector, for inward sourcing of raw materials that was never a concern to most of our industrialists. We believed, when I was in Industry, that if we Nigerians had put great premium on local sourcing of raw materials, the technological ingenuity of Nigerians could have been challenged including the design, development, fabrication and production of simple and affordable local plants and machineries of universal application, tailored to the needs and budget of our people, that hope would have been perfected by now. Nigeria is among many developing countries that had realized that SMEs could do a lot for the economy and so we encouraged them with complex range of measures, touching on finance, technology and infrastructure. Many projects were often run by state promotion agencies, funded by UNIDO, ILO and other donor countries, which provided many tasks from training the promoters to presenting their projects to development banks, later on donors dropped the idea of state promotion as they were keener on new approach geared to private sector for its capacity to initiate and sustain projects.

Although, we don't need to identify winners and losers but the key lesson we must learn from this low economic performance is the absence of vibrant leadership, which does not necessarily come out of political legitimacy especially one leadership that lacks peoples' concern, it is just empty. Again a leader should be conversant with intricate details of governance such as public financial management, planning and organization of development activities, public procurement practice and value for money in the use of public resources. When politicians report for duty in government offices they think that everything in government is simple, but it is this simplest thing that has proven difficult to most of them, particularly to those leaders who exercise judgment independent of their advisers. What I need to explain here is that **state craftsmanship** has to be perfected by a leader. It is the capacity to integrate all encompassing government capabilities, be they political maneuver, economic clout, diplomacy, security; you name it, into an instrument of power i.e a more comprehensive strategy in practice for the leader. What moves a country for good or ill is the proper use or misuse of power.

We may have the right to choose a leader but may not have control over his activities, good or bad. **WHEN WE CHOSE OUR LEADERS WE SHOULD BEAR IN MIND THAT THEY ARE NOT CANDIDATES FOR SAINTHOOD,** expecting them to receive divine revelation. So leaders must be acquainted with government procedures. Only people can solve the problems people created and that is possible only when a leader leads exemplary. We may have differences with our leaders in visioning or in terminology, but even nations differ possibly in basic approach. Russia takes human right to be free health care, free housing, free education, and full employment while America takes human right to be freedom of speech, freedom of press, freedom of religion and free election.

Even if our leaders are saints, we have to devise a concrete roadmap for the control of Gov't plans and strategies in order to avoid any future disruption of national projects or sudden change in policy such as the few examples i.e. projects/plans that we all know, were stopped abruptly. Possibly we have to advice on how the three key organs of government will work together to stabilize on policies and projects to save our country from marking time politically and economically, in one place. National assembly may be asked to appoint Supreme Court as the custodian of major national policies and projects. No President should unilaterally disrupt any of them by stopping, adding or subtracting from any national development programs except with the Supreme Court decision and that will be after hearing from named stakeholders. This may sound

crude but we have to start a control somewhere, somehow, in order to bring stability in the execution of policies or programs of government. Too many sudden disruptions, changes and inconsistencies have slowed down the nations progress, there is abject failure in gov't performance. To make changes happen, Nigerians expect government to lead the effort, however average Nigerian now doubts government commitment to anything, for the following reasons.

1. Past but un-sustained initiative of government like OFN, WAI
2. General distrust of the leadership built over the years
3. Poor or non implementation of past plans and bad financial management

We expect our leaders to make every reasonable effort to be wise and careful, however some of us believe, not wrongly, that it is as useless to try to convince and convert them to "straitjacket" way of operating a gov't, a good job of selling a poor case or is it a poor job of selling a good case, as it is for them to try to convince us that they are on the right path.

Ladies and gentlemen, in some of the above paragraphs, the subjects of leadership and development are touched in general, these are not part of the Theme or subthemes of your conference, I therefore want to end discussing the subjects with a quotation from what Professor Jibril Aminu said at the 30th memorial anniversary of Gen. Murtala Ramat Muhammad, on 13th February 2006 at Mambaya House Kano

> " I do not intend to speak at great length on the topic of leadership question and the quest for Africa's development. It is a hallowed veteran of seminars, books, documents, course units, sermons, documentaries, political lectures and discourses and various commentaries and pep talks of varying degrees of competence and seriousness. In short it is a thoroughly boring topic"

Many people must have a lot to say on your theme and sub-themes, I am sorry to have taken too much of your time. I have just one or two issues remaining. In any country where there is compelling relative weak political position with unimpressive economic performance, there should be linkage between one exercise on improvement and the other. The work of the vision 2010, in particular the one on agriculture, will be relevant to this conference and useful to your institution. It was thoroughly done. For example, (a) plenary sessions were for all members, it examined work done by sub-committees (b) committees provided brain storming (c) workshops captured the views of individuals and the experts (d) memoranda received from the general public were to ensure involvement of every one (e) commissioned studies on topical issues were received from specialized bodies (f) presentation by invited guest speakers were on methodology and unaddressed issues. Because of (1) the voluntary nature of the committee (2) the volume of work involved (3) the time given for the assignment, there were wider consultations to reflect the aspirations of the people. The tools used were (a) Scenario building technique for different possibilities (b) System dynamics for small group sessions to give different ideas on how to solve problems presented in (1) where we are (2) where we want to be (3) how to get there

We were able to (a) define clear objectives (b) develop strategies to achieve aspirations (c) develop action plan (d) establish linkages with other plans. Critical success factors were those problems which will have to be addressed as they were factors that lead the nation to success such as economic, social, cultural through value system, human capital and governing system. After workshop on critical success factors CSF we focused on sustainable economic

sectors and their link to economic growth such as monetary and fiscal policies, trade and distribution, SMEs, mineral resources etc. we then subjected the reports to consensus building processes. How I wish your institution will have a copy of the whole report and work on it. It will help you in REACTIVE PLANNING explained as systematic way of modifying existing objectives, strategies, policies and plans so as to adapt an emerging situation.

Water Resources Development. let me start by saying that development of any agricultural infrastructure is bound to attract criticisms particularly from environmentalists and conservationists but agricultural development and transformation should not be stopped because of such criticisms rather the opponents should proffer solution on how to manage any adverse effects consequential to the execution of the transformation. We believe that such programs are to meet rapid population growth, declining rainfalls, food security, accelerated desertification coupled with numerous socio-climatological dynamics which will all necessitate modern agricultural practices. The high-pitched cries and overbearing (telling people what to do into proud a way) of those who refuse to support our agricultural programs proved strong indication of a group teleguided by powerful external interests as from their reactions, they have no iota of national concern.

We know that every aspect of our agriculture is resting on what the climate dictates. The Nigerian Metrological Agency indicates and raises fears that the global climate change is having devastating impact on the ecological system in Nigeria. The country has become warmer and is experiencing heat waves as the rainy season in the country becomes shorter with the widely reported crop failures and inadequate water availability, as such, the country may lose its ability to feed itself in the near future. The shifting rainfall pattern can make farm land no longer able to support subsistence farming. Distinguished participant, in the face of such situation what will your conference offer as adaptation strategies particularly to the rural poor? Again, if growing periods drop below 90 days, in some areas, maize cultivation, already marginal, will basically no longer be possible as normal agricultural activity, though some season turn out much better than the forecast. Researchers from Nairobi based International Livestock Research Institute and the United Kingdom Waen Association concluded that "in some places, rain could become so scarce that even drought-tolerant crops such as millet will be difficult to grow. In the face of the above, no gov't how ever complacent will just sit down and look.

The NMA predicts that the rains fall in a short period and can be very intensive, resulting in large volume of flows that are lost and recommends that there must be water resource conservation for socio-economic development especially for the supply of more food. Dams and Reservoirs, the world over, particularly in arid and semi-arid regions have been confirmed to create tremendous positive impacts far more than negative effects to both up and downstream communities. Dams with hydropower can be the main economic stay of a region, they ensure all year round agricultural production downstream, they bring about huge socio-economic prosperity, generate employment opportunities. However I know several conferences tend to discount the effect of drought, desertification, rapid population growth, climate change, depleted soil fertilities, geological characteristics and several environmental dynamics which combine to impair the livelihood of communities especially the socio-economic activities just because of naïve reasons. With the many water and environmental scientists that we have, equity and fairness to all riparian communities can be assured, we have the skill required towards integrated

water resources development to satisfy all water users in a basin, including inter basin water transfer to control flooding.

The flooding in Nguru wetland, where UN is legally entrenched in RAMSAR SITE should attract the attention of this conference. All rivers draining into the Nguru wetland have drastically lost their conveyance efficiency through continuous silt deposit arising from desertification and aggressive cultivation, deforestation thereby resulting into incessant flooding and typha grass invasions. The sustainable development and control of the Nguru wetland should not be treated with levity or left in the hands of wetland research organization that has sentimental attachment to RAMSAR SITE. They are linked to the British conservation agency that is only interested in the wildlife and migratory birds. There are recent floodings with lost of life and damage to land and properties in Nguru area, which can not be said to be caused by wild flooding but by carelessness of the authorities, the flood can be turned to mini and micro hydropower source. Artificial flooding assures releases of water to cover known flooding areas thus the farmer is assured of the areas to be flooded, that provides low risk, with increasing production per unit area of land cropped, this affords the wetland people to improve their earning capacity and alleviate their poverty. The reverse is the case with wild flooding. BUT WHAT IS RAMSAR SITE? Correct me where I am wrong.

While Nigeria is striving to maintain a wildlife-friendly environment in the country, it is nevertheless believed that the upliftment of standard of living of the rural people through intensive agriculture could be made possible by assured provision and use of water, so lakes and dams are needed everywhere. The Nguru natural wetland is one of them. We should remember that in 1990s a call was made to declare Hadejia-Nguru wetland, as a RAMSAR AREA **to be a land that must be under the control of the United Nations even if it is within Nigeria.** What an awkward, not graceful, arrangement? Imagine, Nigerian FG has no authority on such a piece of land even though it is within its territory? In whatever circumstances, this arrangement should have been on a limited time but alas, with such declaration, Nigerian gov't can not help to control the flood because the waters are within a RAMSAR SITE. Nguru wetland is a large area that is lying fallow over the years with no visible usage in the near future because it is under the authority of the United Nations. The environmentalists and conservationists have hijacked the areas on behalf of foreign interests, as a safe haven for migratory birds at the expense of the local farming communities. I urge your conference to look deeply into this matter in order to cause something to be done about it. Nigerian gov'ts have to protect their citizens not a foreign authority.

I know your association has nothing to do with housing but please help in the facelift of the rural areas where farmers, your clients, live. Decent and affordable houses for the teaming population of **rural dwellers** were promised by the governments. In this respect it was said, in one of the announcements that "efforts will be intensified at popularizing the use of local raw materials for the construction of houses in LGAs". In my view this effort could also result in capacity building in the creation of new class of artisans, craftsman, tradesman, and technological innovation and production machines in the rural areas. The use of improved local material will result in the facelift of our rural environment that have become eye sore to us and to our visitors, to me it is an environmental degradation. Immediately you get out of an urban area, the country side looks unsuitable for human habitation, no electricity (with plenty of sunshine but no solar system), no water (people still walk miles to fetch water) and because the whole area is on

thatched roof, the materials surrounding the huts, the compounds are all made of stalks/stems of corn, which has to be replaced yearly, the area is therefore vulnerable to fire. No one who knows what life is like in such environment will want to live there, one will not be eager to repeat it if one is lucky to escape.

Individuals cannot be expected **to initiate** social responsibilities beyond paying taxes, so Non-governmental Organizations NGOs have to go headlong in getting people out of this appalling housing situation by devising means of getting semi-permanent affordable building materials for building cheaper houses that can last for many years. I am not asking the government to build houses for the poor as such activities are profit driven, but let us please encourage research and development into our **LAKA, TSAKUWA, CHIYAWA, KARAN GERO AND DAWA ETC** which are the typical building materials in the villages. The Federal Ministry of Works, building materials research section can help in this regards.

I want to localize this part of the presentation, in my plea for our people to have basic human needs, although it relates to ecological zone which is applicable to all parts of Nigeria. The ecology of Bauchi State is such that while in its southern part one can grow two crops of maize in a year, its northern part has a sahelian vegetation. It is an area under dry north-east trade winds where rainfall is lower than 250mm per year, coupled with high sunshine that cause the crops to dry up quickly. The vegetation is very scanty, and the few that are available have adopted to desert conditions. We therefore hold dear our grass and plant roots. Serious mechanization activities will further worsen the land surface. The people there make a hard living, they smile sadly.

The onset of rain is late, and the cessation of rain is early. The cropping season is short, the encroachment of desert is real. The land surface is very fine sand and can not take heavy agricultural machinery, like tractors, combined harvesters etc. Because of the weak soil, farmers there, work with hoes, use only ox-plough and ox-cultivators. They do not adopt to different methods of farming, such as shifting or crop rotation for better production. Use of chemical fertilizer will further damage the soil nutrients. Wind erosion wears away the top soil and immediately leaching, washing away the minerals, starts, therefore the few plants remaining don't have any food from the soil. With the above situation enough food is not produced in the northern part of Bauchi state. I urge that your recommendations should not overlook these facts, if you want us to benefit from the transformation of agriculture.

For the human labour on the farm, we all know that a farmer has to bend down in order to pull the hoe with all his strength, resulting in body pains more especially back pain. The physical body of farmers show early aging, were tied and useless as they look much older than their fashionable, hale and strong city dweller age mates. A farmer spends a lot of time in the farm and gets tired easily, the energy lost on the farm can not be replaced in good time, because they have no body building good food. In arid areas there is no means of employment or earning a living except through farming, even then this occupation is only for subsistence level. Only few hectors of land can be cultivated, this situation discourages people to take to farming. In this area we can hardly pay for modern ways of farming on our own, even with simple and light implements/machines, not only because of weak farm soil, not because of ignorance nor indifference but because of low income earning, we are therefore very grateful for the start of this exercise of transformation of agriculture. It will enable people to have better harvest, make

money from farming, save time and energy, have pleasurable farming, more food to be available in the area. These advantages, if they can be realized, will benefit all Nigerians living above the latitude of 11 degrees north from Sokoto to Borno states.

What will this engineering effort offer to us? At stake in this exercise is the responsibility of every Nigerian professional to contribute to the problem solving, remembering that such conferences are what you, organizers, make of them. In national development, it is said, that "technology is the engine of growth, business and industry are the drivers, gov't is the catalyst and academics are the fuel", your fuel is not the one subject to oil subsidy, it is knowledge, skill and materials, so over to you, academicians and professionals. I now doubt gov'ts ability to be the catalyst because of its poor achievement of 2012 budge execution put at 13.7%. I also doubt Govts continued ability to finance the programmes you may propose. Let us insist on putting an agricultural transformation levy on Oil Companies, on their exports and any oil imports for bridging, like we levy on sugar importers who pay levy for sugar development, again companies in general pay levy to raise the level of educational infrastructures (Educational Trust Fund, ETF). We knew that all petroleum products buyers contributed to PTF through increase in Oil Pumps Prices. We should not compromise on JUDICIOUS USE of all collections. May be you have to copy and adopt the forces that brought about the success of **pure water** enterprises, there was no government hand in it at all, it was developed purely by the private sector. We have to get out of the syndrome of getting government into everything. Your conference should be a revolutionary experiment of not necessarily involving government central planning but base your recommendations on private sector effort to be supported by promotional campaign. I urge all professionals to kindly stretch their hands down to pull up others to be more useful to the society. Your exercise should recognize that extension services are the primary vehicles for the diffusion of knowledge and new technology to the peasant farmers.

Finally I want to reiterate my favorite quotation to Nigerian Society of Engineers, Bauchi Branch, which I read at the inauguration dinner of their new executive committee in March, 2007

> I copied in a book, the title of which I can't remember now some sentences such as "a society, it is said, is judged by the qualities it admires. If you want to determine the possibility of progress of a nation you should look at the state of technological arts and status of the intellectuals in the society. Are they revered, respected, honoured? Are they held in contempt by the political authorities and by the society? Are they consulted regularly in the formulation of ideas and in the making of policy? These questions and many more must be answered by all of us to know where our professionals stand. After many years of general disorder of the public mind can we now get out of the intellectual chaos in which our society seem embedded? In addition to the questions above I will join this, how do we free the creative energies and impulses of our engineers and technologists in the face of the requirement of such energies, in **quality, quantity and timing?"**

Related to this is what I will wish your institution to know, that in the 1970s there was a lot of debate concerning the preparedness and technological take-off of Nigeria. A conference on Development of Indigenous Technology was held at Enugu (February, 1981), you have to dig the records out, where minimum necessary condition for the technological take-off of Nigeria was discussed and the lopsided nature of Nigeria's development in technical education was analysed. It was found that there was an average of one technician/technologist to about 9 engineers in Yaba College, Nigeria, exactly the opposite required for technological development of any

economy. I remember too when I was Federal Permanent Secretary Ministry of Communication in 1976 the pyramid for professional staff recruitment was, I Engineer to look after 3 technologists and 9 technicians. Dr. Emmanuel O. Egbogah said "the situation has worsened today as many vocational and middle level manpower development institutions, the polytechnics are being converted to degree-awarding institutions".

Historically no economy has ever become developed with this skew in their system of education and training for national manpower supply and/or human capital development. I suspect that such poor manpower planning is happening in the agricultural sector too. I am aware of and I hope something will be raised on what is contained in the following statement "frustrated out of the system by lack of facilities to work with, Nigerian intellectuals and professionals have been seeking and receiving refuge abroad where facilities are provided and their services and contributions appreciated"

When I was the SGF, I maintained a good working relationship with Nigerians in Diaspora Groups and got a lot of information, one of which was that there were in 1995 over 20,000 Nigerian Medical Doctors in USA. We then set up programs to bring every body back home, from there and from elsewhere, by making Nigeria the most preferred nation for all Nigerians. For a start, we tested our ability, to embark on nationwide program, with no outside help, by setting up and executing PTF, and it PTF, was said to have worked very well. On such solid ground, prospects, we made amends and cast vision 2010 for Nigeria. However, both PTF and vision 2010 were stopped crudely by Obasanjo Administration.

I thank you very much for listening and God bless.

Alh. (Dr) Aminu Saleh, **CFR, GCON,**
Wamban Katagum

TABLE OF CONTENTS

Title Page iii
Preface iv
LOC Mission Statement v
National Executive Council vi
Central Local Organizing Committee vi
Sub-Committees vi
Keynote Address and Opinion Paper ix
ENGINEERING THE AGRICULTURAL TRANSFORMATION AGENDA
ALHAJI (DR) AMINU SALEH,CFR, GCON (WAMBAN KATAGUM)
Table of Contents xxiv

SECTION I: POWER AND MACHINERY

EFFECTS OF MOISTURE CONTENT, IMPLEMENT SPEED AND TILLAGE DEPTH ON SOIL BULK DENSITY USING TWO PRIMARY TILLAGE TOOLS.
Abubakar, Y., Abdulkadir, S. A., Jahun, B. G.and Suleiman, M. H. 1

CAPACITIVE PERFORMANCE STUDIES OF SELECTED TILLAGE OPERATIONS
Afolabi, A., Gwarzo, M. A. and Ohinoyi, F. G. 2

MECHANIZATION OF FIELD OPERATIONS IN CASSAVA PRODUCTION: CHALLENGES AND PROSPECTS
M.C. Ikejiofor and J.C. Adama 12

EFFECTS OF SELECTED FACTORS ON PERFORMANCE OF A MOTORIZED MILLET THRESHER
Abubakar, L.G. and Abdulsalam, M. 18

ESTIMATION OF SUITABLE FIELDWORK DAYS FOR PLANTING AND HARVESTING OPERATIONS OF MAIZE PRODUCTION IN BAUCHI LGA
Jahun, B. G., Iya, S. A. and Abubakar Y. 27

DETERMINATION OF PHYSICAL AND MECHANICAL PROPERTIES OF A SOIL RELATED TO THE DESIGN OF TILLAGE IMPLEMENTS
M.S. Abubakar and S.K. Shittu 33

THE EFFECT OF SOIL MOISTURE CONTENT AND DEPTH OF PLOWING ON WHEEL SLIP ON A SANDY LOAM SOIL
Sule, S.,Ohanwe, C. N. and Atanu, S. O. 41

TRANSPORTATION OF AGRICULTURAL PRODUCE AND CONSTRAINTS ON VALUE-ADDITION IN PARTS OF RURAL NIGERIA
Usman, D. D., Mohammed, B. and Haque, M. A. 50

ECONOMICS OF TRACTOR HIRING AND LABOUR COST IN LAND REPARATION IN SOUTHWEST AGRO-ECOLOGICAL ZONE OF NIGERIA: ALTERNATIVE FOR AGRICULTURAL TRANSFORMATION AGENDA
Wahab, A. A.,Issa, F. O., Arab, I. A. and Sale, N. A. 67

ADAPTATION OF A PAIR-LOADER HYDRAULIC RAM AS A DRAWBAR DYNAMOMETER
Ezema, A. O. and Obi, O. F. 72

AGRICULTURAL PRODUCTION IN TWO URBAN AREAS OF NIGERIA: A FIELD EVALUATION
Adama, J. C. andOnwualu, A.P. 78

DEVELOPMENT OF HAND PUSH MECHANICAL WEEDER
Muhammad, A.I. and Attanda, M. L. 89

DEVELOPMENT OF MODEL FOR PREDICTING YIELD OF MAIZE USING PLANT HEIGHT, MEAN EMERGENCE DATE, MEAN EMERGENCE RATE AND EMERGENCE RATE INDEX
Abdulkadir Salihu Ahmed and ShehuAdamuIya 99

ESTIMATING TIMELINESS COST FOR PLANTING AND HARVESTING OPERATIONS IN SEMI-MECHANIZED FARM IN BAUCHI STATE NIGERIA
B. G. Jahun and S.A. Iya 109

SORGHUM CROP GRAIN YIELD MODEL IN A SEMI-ARID REGION OF NIGERIA
Dauda, A., Ohu, J. O. and Usman, B. 114

SECTION II: SOIL AND WATER ENGINEERING 126

OPPORTUNITIES FOR EFFECTIVE MANAGEMENT OF IRRIGATION WATER AT FIELD LEVEL
H. E. Igbadun and I. E. Ahaneku 127

A REVIEW ON THE USE OF DRIP IRRIGATION IN NIGERIA
Oiganji Ezekiel, O.E Nwafor and A. Ahmed 139

MORINGA OLEIFERA FOR WATER PURIFICATION
G.I. Ezenne and C. S. Abana 148

INFLUENCE OF RICE HUSK ON BULK DENSITY OF FADAMA SOILS
Abubakar A. S and Abdullahi A. S 156

POTABLE WATER STORAGE AND DISTRIBUTION SYSTEMS IN ENUGU URBAN
J. C. ADAMA and G.O. CHUKWUMA 160

COMMUNITY-BASED ADAPTIVE MEASURES: IMPERATIVE FOR EFFECTIVE CLIMATE CHANGE ADAPTATION STRATEGY IN AFRICAN AGRICULTURE
Obi, O. F., Ugwuishiwu, B. O. and Nwakaire, J. N. 168

EVALUATION OF SOIL AND WATER QUALITY OF WATARI IRRIGATION PROJECT IN SEMI-ARID REGION, KANO, NIGERIA
N.J. Shanono M.K. Othman, N.M. Nasidi and H. Isma'il 181

ASSESSMENT OF IRRIGATION WATER AND SOIL QUALITY IN GALMA IRRIGATION SCHEME, ZARIA, NIGERIA
Othman, M. K., Ismail, H. andIorhen, O. E. 187

DEVELOPMENT OF IRRIGATION FIELD LABORATORY: DESIGN, CONSTRUCTION AND CALIBRATION OF MICRO WATER RETENTION AND OFF-TAKE STRUCTURES
H. Ismail, M. K. Othmanand N. J. Shanono 194

WATER BUDGET FOR MAIZE AND SORGHUM IN SAMARU ZARIA, NIGERIA
Othman, M.K. H. Ismail and S. Mustapha 200

BACTERIOLOGICAL ANALYSIS OF HAND- DUG WELL WATER IN DEMSA LOCAL GOVERNMENT AREA, NIGERIA
Tya, T.S.K., Umaru, A. B. andBarmamu, B. R. 209

IMPACT OF CLIMATE CHANGE ON AGRICULTURE AND FOOD SECURITY
G. A. Fumen; E. F. Aiyejagbara; S. B. Igboro and Z. D. Osunde 214

MANAGING FLOODS IN NSUKKA URBAN WITH CLIMATE CHANGE
G. I. Ezenne, C.C. Mbajiorgu and M. Okechukwu 224

VAGARIES OF CLIMATE AND FARMER ADAPTATION FOR SURVIVAL IN THE FADAMA OF BAUCHI STATE, NIGERIA
Ibrahim, A.U. ; Musa, S.M and Mofoke, A. L. E 236

WASTEWATER REUSE PRACTICE IN NIGERIA: THE IRRIGATION PERSPECTIVE
Onwuegbunam D.O., Oyebode, M.A., Igbadun, H. E., Onwuegbunam, N.E. andSobowale, A. 246

SECTION III: POST HARVEST ENGINEERING 252

SELECTED MOISTURE DEPENDENT PHYSICAL PROPERTIES OF COMMON BEANS, COWPEA AND YARD-LONG BEANS
Ndukwu M.C, Adama J.C 253

DEVELOPMENT OF A DIFFUSE LIGHT STORE FOR "SEED" POTATO STORAGE
F.A. Babarinsa and Williams, J.O. 263

ELECTRICAL RESISTIVITY AND CONDUCTIVITY OF IRVINGIAGABONENSIS AND MUCUNAFLAGELLIPES AT DIFFERENT TEMPERATURES AND THEIR RELATIONSHIPS WITH SOME PHYSICAL PROPERTIES
Ndukwu M.C andNwauisi K.O 271

EFFECT OF PROCESSING CONDITIONS ON THE WHOLENESS OF CASHEW KERNELS USING STEAM BOILING METHOD
Obi, O. F.,Nwakaire, J. N., Aneke, N. N.,Ezeoha, S. L. and Nwagugu, N. I. 280

SOME STUDIES ON THE DRYING OF DIKA NUT
Aneke, N. N., Obi, O. F. and Nwakaire, J. N. 286

SOME ENGINEERING PROPERTIES OF PROSOPIS AFRICANA (OKPEYE) SEEDS
ASOIRO, F.U., NWOKE,O.A., and EZENNE,G.I. 298

EFFECT OF MOISTURE CONTENT ON THE STATIC COEFFICIENT OF FRICTION OF SELECTED CEREALS AND LEGUMES IN NIGERIA
N.A. Aviara., A. A. Lawal., S.A. Rimamnuskep and S.A. Adimora 313

PHYSICAL AND MICROBIOLOGICAL QUALITY ATTRIBUTES OF PACKAGED GARI AT VARIOUS INITIAL MOISTURE CONTENTIN STORAGE
Adejumo, B. A. 324

A COMPARATIVE ANALYSIS OF THE PERFORMANCE EVALUATION OF TWO ON-FARM FRUITS AND VEGETABLE STORAGE STRUCTURES
Adejumo, B. A. 330

DEVELOPMENT OF A DOUM PALM HUSKING MACHINE
O.K. Fadele, M. Obochi1 and N. E. Onwuegbunam 340

DEVELOPMENT OF AN IMPROVED MOTORIZED OIL PALM FRUITBUNCH STRIPPER
Olotu, F.BandObiakor, S.I 347

EFFECT OF PROCESSING METHODS ON THE PHYSICO-CHEMICAL PROPERTIES OF THE PALM OIL OBTAINED FROM OIL PALM FRUIT.
Bolarin F. M. And Obiakor,S. I. 357

DESIGN AND CONSTRUCTION OF EGG INCUBATORWITH FAULT ANALYSIS ALERT CONTROL SYSTEM USING SHORT MESSAGE SERVICE (SMS) FOR AGRICULTURAL FARMSTEAD
Uzoigwe, L.O.,Mbajiorgu, C.C.andMaduakolam, S.C. 366

SOME PROPERTIES OF ALMOND FRUITS AS RELATED TO MECHANICAL CRACKING
Alonge, A. F.andOmoniyi, T. E. 389

AGRICULTURAL WASTE CONCEPT, GENERATION, UTILIZATION AND MANAGEMENT
Obi, O. F., Ugwuishiwu, B. O. and Nwakaire, J. N. 395

DESIGN, DEVELOPMENT AND PERFORMANCE EVALUATION OF AN ELECTRONICALLY AUTOMATED INCUBATOR
Ahmad, K., Musa, M. J.andMukhtar, Y. 407

ASSESMENT OF WEAR ELEMENTS IN FOOD PRODUCT BY DRY MILLING USING ATOMIC ABSORPTION SPECTROSCOPY TECHNIQUE
Ahmad H. I., Jahun, B. G. and Abubakar, S. M. 417

DEVELOPMENT AND PERFORMANCE EVALUATION OF PACKAGING METHODS FOR FRESH TOMATO IN BORNO STATE, A SEMI ARID ENVIRONMENT
Dzivama, A.U. Lawal, A. A. and Saidu,M.J. 422

MOISTURE SORPTION OF DRIED TOMATO FLAKES AT DIFFERENT TEMPERATURES
S. K. Shittu, A.M.I. El-Okene, M.Isiaka and M.L. Suleiman 432

EFFECT OF MOISTURE CONTENT ON THE STATIC COEFFICIENT OF FRICTION OF SELECTED CEREALS AND LEGUMES IN NIGERIA
N.A. Aviara., A. A. Lawal., S.A. Rimamnuskep and S.A. Adimora 440

EFFECT OF MOISTURE CONTENT, PARTICLE SIZE AND TEMPERATURE ON THE SPECIFIC HEAT OF PRESERVED GROUND SHEANUT KERNEL (*BUTYROSPERNUMPARADOXUM*)
Nwannewuihe, H.U, Onwukwe M. C., Edeh J.C and Nwagugu N. I. 450

SPEED BASED PERFORMANCE TRENDS FOR A CENTRIFUGAL HULLER DEVELOPED FOR SUNFLOWER SEEDS
Abubakar, L.G. and Akangbe, O.L. 465

EFFECT OF SOME PHYSICO-MECHANICAL PROPERTIES ON MECHANICAL PEELING OF CASSAVA TUBERS
Jimoh, M.O., Olukunle, O.J., Ademosun, O.C. and Manuwa, S.I. 477

DEVELOPMENT AND PERFORMANCE EVALUATION OF THE CLEANING SYSTEM OF THE SWARAJ THRESHER
Ali M. A., Usman, A.G., and Lawan, I. 487

ESTIMATED EQUATIONS FOR TIME, WATER AND ENERGY REQUIMENTS IN COOKING RICE
R Akinoso, Aremu A.K. and T. T. Oyegunle 495

SECTION IV: FARM STRUCTURES AND ENVIRONMENTAL CONTROL ENGINEERING 502

ENGINEERING STRUCTURE IN A TYPICAL SMALL SCALE COCOA PROCESSING INDUSTRY IN ILE-OLUJI, ONDO STATE OF NIGERIA
Omoniyi, T. E, Akinyemi B.A. Olasoji O.M. 503

PERFORMANCE CHARACTERISTICS OF GUM ARABIC BONDED PARTICLEBOARD MADE FROM RICE HUSK
Ndububa E. E. 513

PHYSICAL AND CHEMICAL PROPERTIES OF GIDAN-KWANU TERMITE HILL
B. A. Alabadan and E. F. Omosekeji 524

OIL REMOVAL FROM PRODUCED WATER USING BANANA PEEL
I.M. Muhammad1, U.A. El-Nafaty, and S. Abdulsalam 533

SECTION V: EMERGING TECHNOLOGIES IN AGRICULTURAL 547
ENGINEERINGBIOMASS BRIQUETTING AND ITS PERSPECTIVES IN NIGERIA
Obi, O. F., Akubuo, C. O. and Okonkwo, W. I. 548

REPOSITIONING AGRICULTURAL DEVELOPMENT IN AFRICA THROUGH APPROPRIATE TECHNOLOGY TRANSFER
Obi, O. F., Nwaikaire, J. N.,Okonkwo, W. I., Ugwuishiwu, B. O. and Anyadike C. C. 556

PRODUCTION OF BIODIESEL FROM USED VEGETABLE OIL
AlabadanB.A.and J. A. Godwin 567

COMPARATIVE STUDY OF THE EFFECTS OF TREATMENT TECHNIQUES ON THE MECHANICAL PROPERTIES OF KENAF (*HIBISCUS CANABINUS)* FIBRE REINFORCED BRAKE PADS
Namessan, N.O., J.N. Maduako., S.A Iya and B. Aliyu 581

SECTION I

FARM POWER AND MACHINERY

EFFECTS OF MOISTURE CONTENT, IMPLEMENT SPEED AND TILLAGE DEPTH ON SOIL BULK DENSITY USING TWO PRIMARY TILLAGE TOOLS.

Abubakar, Y.[1], Abdulkadir, S. A.[2], Jahun, B. G.[3]and Suleiman, M. H.[1]

[1]Department of Agricultural and Bio-Environmental Engineering, Federal Polytechnic, P.M.B. 35, Mubi, Adamawa State, Nigeria.yahayaabubakar70@gmail.com

[2]Department of Agricultural Engineering, Adamawa State Polytechnic, Yola, Adamawa State, Nigeria.salihuabdu110@yahoo.com

[3]Department of Agricultural Engineering, AbubakarTafawa-Balewa University, Bauchi, Nigeria.bgjahun@yahoo.com

ABSTRACT

Investigation was carried out on the effects of soil moisture content implement speed and tillage depth on soil bulk density using disc and mouldboard ploughs on loamy sand soils. Analysis of variance and Duncan's multiple range tests show that moisture content, implement speed and tillage depth have significant effects on soil bulk density. Further analysis revealed that, at 1.94m/s (7Km/h) implement speed, the soil bulk density reduced to minimum considerably and usually maintain a constant value whichequals the values recorded at implements speed of 2.5m/s (9Km/h) and 2.78m/s (10Km/h). This shows that, the physical properties of soil required for good soil tillage could be achieved at implement speed of 7km/h.

Keywords; Bulk Density, Tillage Depth, Soil Moisture and Implement Speed.

1. INTRODUCTION

Conventional tillage practices modify soil structure by changing its physical properties such as soil bulk density, soil penetration resistance and soil moisture content. Tillage, the physical modification of soil, is performed using various methods. This is usually accomplished through the use of manual hoe, tractorized and animal drawn implements. The main purposes include tilt formation, weed control, enhancement of soil aeration, drainage and incorporation of residues and fertilizers. Root and crop growth is facilitated. Also seepage and storage of water are enhanced. Tillage also controls disease and pest infestation.Soil tillage is one of the fundamental agro-technical operations in agriculture because of its influence on soil properties, environment and crop in general. The aim of soil tillage in crop production is to produce soil conditions and environment favourable to crop growth by changing the soil bulk density, soil aggregate, size distribution and other characteristics of soil, (Johnson and Buchele, 1967).It is a process of modifying soil properties by pulverization, cutting, inversion or movement of the soil resulting in improved soil condition for optimal crop growth and yield, (Grisso et al, 1996). It is a major event in the process of crop production, which consumes nearly 30 – 35 percent of the total energy requirements, (Manian et al, 2000). Tillage tools and implements are used to produce those favourable soil conditions. The aim of this work is to determine the effects of implement speed variations, depth of tillage and moisture content on soil bulk density using disc and mouldboard ploughs.

2. MATERIALS AND METHODS

The study was conducted at the demonstration farm of the department of Agricultural and Environmental Engineering, ModibboAdama University of Technology, Yola during the year 2010. Soil particle size distribution analysis showed the soil to be loamy sand (Sand - 76%, Silt –

15% and clay – 9%). At the period of this experiment, the field looks like fadama area, and lies on a gentle slope.

The equipment consist of a conventional tractor, disc and mouldboard ploughs, an oven drier for analyzing moisture content of soil and weighing balance.

2.1. Experimental Design

The test was carried out using a disc and mouldboard ploughs. For tillage operations, the treatments include; moisture content (M) of the soil (before and after rainfall) at two (2) levels, implement speed (S) five (5) levels, depth of ploughing (D) two 2 levels and three replications for each test. The four variables were combined in a factorial split-plot design with three blocks.
Split-plot design is generally suitable for factorial experimental with three or more factors (Gomez and Gomez, 1984). The moisture levels were designated as M_1 and M_2, and where M_2 corresponds to normal moisture content for ploughing (20hr after rainfall), and M_1 was drier than M_2 (six days after rainfall). Implement speed levels were 3, 5, 7, 9, and 10km/hr since average speed of ploughing is about 7km/hr (Ahanekun et al, 2003).

Soil properties were determined before and after tillage treatments. The physical field layout was achieved by using Pegs and color tags, field measuring tapes and lines to mark out the sub plot and the strips.

2.2. Determination of Soil Properties

In order to define the initial soil conditions, soil samples were collected from each treatment to determine the soil parameters. Soil properties measured include: soil moisture content and bulk density.

2.2.1. Determination of Soil Moisture Content

The soil moisture content was determined gravimetrically. Soil sample for each treatment was taken before and after tillage operations, and placed in an air tight container (tin). The sample was immediately taken to the laboratory and weighed with an accurate weight balance and then placed for an oven drying at a temperature of 110^0 C for 24 hours as in Gwarzo, (1990).

The loss of weight in drying divided by the original weight of individual soil sample multiplied by one hundred percent (100%) as shown in the equation below determines the moisture percentages of the soil samples on dry basis

$$Mdb = \frac{W\omega - Wd}{Wd} \times 100 \qquad \text{(James,1988)} \qquad (1)$$

Where

Mdb = Moisture content of the soil (%db)

$W\omega$ = Weight of moist soil (g)

Wd =Weight of dry soil (g)

The results of the soil moisture content before and after tillage were presented in appendix 6 and the average values of the results for each treatments was presented on appendix 4, showing data for before and after tillage respectively.

2.2.2. Determination of Bulk Density

The bulk density determination was carried out on intact core samples as described by Blake and Hartage (1986) at a depth of 0 – 20cm taken from each treatment before and after ploughing. Samples were oven dried in laboratory at 105^0c for 48 hours. The bulk density of the soil was determined from the following relationship.

$$p_b = \frac{Mds}{\Pi r^2 h} \qquad (2)$$

Where

p_b = Bulk density g/cm^3

Mds = Mass of oven dry soil sample g

Π = 3.142

H = height of ring (m)

r = radius of the ring (m)

The data obtained for the soil bulk density before and after tillage operations were presented in appendix 4 and 5 respectively, and also subjected to analysis of variance for significance test base on the interactions of implement type, plough speed, tillage depth and moisture content Table 6.

2.3. Determination of Machine Parameter

Mersey Ferguson 375 and John Deere tractors were used to perform the experiments. The machine parameters determined was the tractor speed.

2.3.1. Determination of Tractor Speed

Five treatments of the tractor speeds chosen were 3, 5, 7, 9, and 10 km/hr corresponding to S_1, S_2, S_3, S_4 and S_5 respectively. Before the actual experiments starts, the various revolutions per minute of the engine read off from the speedometer that corresponds to the chosen tractor forward speeds were determined. This is to ensure that the tractor attains such speeds before measurement at joint up pulls was taken under each soil moisture regime.

2.4. Data Collection and Analysis

Data was collected as described under research methodology. The average values of the results obtained were presented on Table 1. This result was subjected to Analysis of variance ANOVA to evaluate the significance of each treatment in a split –plot design with a factorial treatment design of 2×2×2×5. This was to determine the effect of soil moisture, tool speed, depth of cut, and combine effect of moisture content, tool speed, tillage depth on the soil bulk density after tillage.

Comparison of means was performed with Duncan's Multiple Range Tests to determine the significance of each treatment on soil bulk density at $P< 0.05\%$.

However, results for bulk density were illustrated graphically to show the influence of moisture content, forward speed and depth of cut on bulk density of the soil using disc and mouldboard ploughs in figures 1and 2.

3. RESULTS AND DISCUSSION

The average values for the results of soil bulk density before and after tillage were presented in Table 1 below. Table 1 shows the average values for bulk density of the soil on each treatment plot before and after tillage. The result shows that, the bulk density of the treatment plots before tillage slightly varies from one plot to the other. The values range from 1.160 g/cm^3 to 1.196 g/cm^3 before rainfall(lower moisture level M_1) and 1.161 g/cm^3 to 1.198 g/cm^3 after rainfall (higher moisture level M_2).The table also shows the values of bulk density of the soil after tillage. Bulk density of the soil decreases with increase in the speed of implement, but it increases with increase in depth of tillage from 15 – 19 cm for disc and mouldboard ploughs and at the two moisture levels in consideration.

Figure 1(a) below illustrated that, bulk density of the soil decreases from 1.12kg/cm^3 to 1.099kg/cm^3 and continue to decrease for every increase in speed to1.033kg/cm^3 for 3km/hr, 5km/hr and up to 10km/hr respectively and also, at 3km/hr (0.83m/s) bulk density increases from 1.12kg/cm^3 to 1.169kg/cm^3 for tillage depth of 15cm and 19cm respectively and it continues to decrease for every increase in speed for the soil under consideration, when disc plough was used at 6.58% db.

Figure 1(b) illustrated that, bulk density decreases from 1.119kg/cm^3 to 1.117, 1.114, 1.090 and 1.08kg/cm^3 with increase in speeds of 3, 5, 7, 9 and 10km/hr respectively, whenmouldboard plough was used at 6.58% db. The bulk density increases with increase in tillage depth from 15cm to 19cm.

Figures 2(a) and 2(b) illustrated the influence of speed, tillage depth and moisture content on bulk density of the soil at 10.47% db. Bulk density of the soil decreases from 1.169 to 1.148 and 1.119kg/cm^3 at implement speeds of 3, 5 and 7km/hr respectively and finally decreased to a constant value of 1.111kg/cm^3 for the speeds of 9km/hr and 10km/hr when disc plough was used. And bulk density increases with increase in tillage depth from 15cm to 19cm in all the speed levels. In figure 2(b), mouldboard plough was used. Bulk density decreases with increase in speed of implement, but increases with increase in tillage depth from 15cm to 19cm. It was observed that, the values of bulk density recorded at 10.47% db were greater than that obtained at 6.58% db for every speed of implement and tillage depths.

The analysis of variance ANOVA in table 2 for the effects of implement speed, tillage depth and moisture content on bulk density shows that, soil moisture content (M), implement type (I) and tillage depths (D) were not significant. The table indicates that, the individual effect these factors in tillage operation does not affect the bulk density of the soil significantly, but the effect implement speed is highly significant on bulk density of the soil. This indicates that, with any increase in forward speed of operation, for either disc or mouldboard ploughs at the same tillage depth, a significant change in bulk density of the soil occurred. The interactions between moisture content and implement (M×I), moisture content and tillage depth (M×D), and implement and tillage depth (I×D) were highly significant on bulk density. The combine effects of moisture content, implement type (disc and mouldboard ploughs) and tillage depth (M×I×D) were highly significant on bulk density as shown in Table 1. Considering the subplot factor in split-plot

design, the analysis of variance Table 2, it shows that, implement speed (S) and the interaction of main-plot and sub-plot factors were significant on bulk density, but the analysis Table 2 shows that the interaction between implement speed andmoisture content was not significant at 1% and 5% level of significance.

The comparison test with Duncan's Multiple Range Tests (DMRT) Table 3 (appendix 4) shows that the effects of implement speed (S),moisture content (M), implement type (I) and tillage depth (D) were significant on bulk density at $P < 0.05$ and letters **a, b, c** up to letter **t** were used to indicate the significance of each treatment on bulk density. Treatments with the same letters are significantly not different at $P < 0.05$. The DMRT shows that, the treatment with the highest value of bulk density was indicated by letter "**a**". The treatment comprises of operating speed (S_1) of 0.83 m/s, average moisture content (M_2) 10.47% db, using disc plough (I_1) at tillage depth (D_2) 19 cm. The treatment with the lowest bulk density was indicated by letter "**t**" and comprises of moisture content (M_1) 6.58% db, implement speed (S_5) 10km/hr, implement type disc plough (I_1) and tillage depth (D_1) 15 cm.

4. CONCLUSION

Field investigation was carried out on the effects of soil moisture content, implement speed and tillage depth on soil bulk density using disc and mouldboard ploughs on loamy sand soils at the ModibboAdama University of Technology, Yola, Agricultural engineering research farm.

The variables were combined in a factorial split-plot design with three blocks. Soil properties (moisture content and bulk density) were determined before and after tillage on each treatment. Soil disturbance were measured during the tests.
Analysis of variance, Duncan's multiple range tests and graphical figures shows that, moisture content, implement speed and tillage depth have significant effects on bulk density of the soil.
The analysis further revealed that, at 1.94m/s (7Km/h) implement speed, the physical properties of the soil (bulk density) reduced to minimum considerably and usually maintain a constant value whichequals the values recorded at implements speed of 2.5m/s (9Km/h) and 2.78m/s (10Km/h) . This shows that, the physical properties of soil required for good soil tillage could be achieved at implement speed of 7km/h.

1. The study also revealed that, at 7Km/hr and average soil moisture level of 10.47%db, bulk density of the soil, was reduced to the lowest value and produced good soil tillage. Therefore, the speed level is recommended for tillage, considering the soil under study.
2. In case of further studies on the soil under consideration, the use of three (3) moisture level may reveal additional information on the soil.

REFERENCES

Ahanekun, I.E.,;Onwualu, A.P.; James, D. and Ani, A.O. (2003). Effect of Soil Moisture and Tools Speed on Draught and Power Requirement of Disc Plough; Proceedings of the 4thInternational Conference and 25th Annual General Meeting of the Nigerian Institute of

Blake, S.R. and Hartge, K.H. (1986). Bulk Density Core Method, In Method of Soil Analysis Part I Physical and Mineralogical Properties. Klute, A. (eds) Agronomy Monograph 9, American Society of Argon Madison, Wisconsin PP.363 – 366.

Gomez, K. A. and Gomez A.A. (1984) Statistical Procedures for Agricultural Researches, 2nd Edition, John Wiley and Sons. Inc., New York

Grisso, R.D, Yasin M and Kocher, M.F. (1996). Tillage Implements Force Operating in Salty Clay Loam. Trans of the ASAE 39(6): 1977-1982.

Gwarzo, M.A.S. (1990). Capacitive Performance Study and Optimisation of Power and Machinery on a Large Scale Farm.Ph.D Thesis Department of Agricultural Engineering Ahmadu Bello University, Zaria.

James, L.G. (1988). Principles of Farm Irrigation System Design. New York John Willey Krieger Publishing Company.

Johnson, C.E. and Buchele, W.F. (1967).Energy in Clod-Size Reduction of Vibratory Tillage.Trans. of the ASAE, 12(3): 371-374

Manian, R. Kathirvel, k. and Rao, V. R. (2000): Influence of Operating and Disc Parameters on Performance of Disc Tools. AMA Vol. 31 (2): 19-22

Table 1. Average values of bulk density of soil before and after tillage

Implement	speed (m/s)	Depth 1	Depth 2	Depth 1	Depth 2
Moisture level (M_1)	**6.58%db**				
Disc plough	0.83	1.117	1.186	1.120	1.169
	1.37	1.176	1.192	1.099	1.158
	1.94	1.176	1.171	1.075	1.120
	2.5	1.187	1.175	1.059	1.066
	2.79	1.181	1.181	1.033	1.066
Mouldboard Plough	0.83	1.194	1.188	1.199	1.135
	1.37	1.196	1.176	1.117	1.132
	1.94	1.173	1.184	1.114	1.128
	2.5	1.188	1.176	1.090	1.112
	2.79	1.173	1.178	1.111	1.085
Moisture level (M_2)	10.47% db				
Disc plough	0.83	1.192	1.193	1.169	1.197
	1.37	1.188	1.188	1.148	1.157
	1.94	1.183	1.183	1.119	1.140
	2.5	1.171	1.185	1.111	1.114
	2.79	1.181	1.178	1.111	1.085
Mouldboard plough	0.83	1.185	1.196	1.166	1.195
	1.37	1.186	1.190	1.151	1.173
	1.94	1.176	1.189	1.129	1.150
	2.5	1.184	1.183	1.126	1.144
	2.79	1.181	1.167	1.093	1.138

Table 2: Effects of the factors studied on bulk density

Source of variation	DF	SM	MS	F	F (1%)	F (5%)
Replication	2	0.00104855	0.000524	0.000118 ^{ns}	3.75	6.51
Main-plot factor	7	62.4113	8.9159	2.0109 ^{ns}	2.77	4.28
Moisture(M)	1	0.03265	0.03265	0.007364 ^{ns}	4.60	8.86
Implement(I)	1	0.215	0.215	0.0485 ^{ns}	4.60	8.86
Depth(D)	1	0.0914	0.0914	0.02061^{ns}	4.60	8.86
M×I	1	151.5615	151.5615	34.18398 **	4.60	8.86
M×D	1	151.6851	151.6851	34.2119 **	4.60	8.86
D×I	1	151.7498	151.7498	34.22645 **	4.60	8.86
M×I×D	1	57.243	57.243	12.9109 **	4.60	8.86
Error(a)	14	62.07225	4.4337			
Subplot factor(S)	4	0.0725	0.018125	11.6677**	1.48	3.56
Main × sub-plot factor:	39	0.15779093	0.004046	2.6045*	1.54	1.84
S×M	4	-136.177	-34.04425	-21915.52^{ns}	1.48	3.56
S×I	4	139.26	34.815	22417.9 **	1.48	3.56
S×D	4	815.13	203.783	131218.6 **	1.48	3.56
S×M×I×D	4	12.527	3.132	2016.58 **	1.48	3.56
Error(b)	80	0.1242745	0.001553			
Total	119					

M=Moisture Content,I= Implement, D= Depth, S=Speed of operation, **Highly significant,^{ns} Not significant.

Table 3: Bulk density data

S/No	Treatments	Bulk Density		S/No	treatments	Bulk Density	
1.	$S_1M_1I_1D_1$	1.1203	hijklmn	21.	$S_3M_2I_1D_1$	1.119	hijklmn
2.	$S_1M_1I_1D_2$	1.169	bc	22.	$S_3M_2I_1D_2$	1.14	efghi
3.	$S_1M_1I_2D_1$	1.124	ghijkl	23.	$S_3M_2I_2D_1$	1.129	fghijkl
4.	$S_1M_1I_2D_2$	1.135	efghijk	24.	$S_3M_2I_2D_2$	1.1497	cdef
5.	$S_1M_2I_1D_1$	1.169	bc	25.	$S_4M_1I_1D_1$	1.0513	st
6.	$S_1M_2I_1D_2$	1.196	a	26.	$S_4M_1I_1D_2$	1.066	rs
7.	$S_1M_2I_2D_1$	1.167	bcd	27.	$S_4M_1I_2D_1$	1.097	nop
8.	$S_1M_2I_2D_2$	1.195	a	28.	$S_4M_1I_2D_2$	1.124	ghijklmn
9.	$S_2M_1I_1D_1$	1.0667	ab	29.	$S_4M_2I_1D_1$	1.1113	klmno
10.	$S_2M_1I_1D_2$	0.733	ab	30.	$S_4M_2I_1D_2$	1.114	jklmno
11.	$S_2M_1I_2D_1$	1.1203	hijklmn	31.	$S_4M_2I_2D_1$	1.126	fghijkl
12.	$S_2M_1I_2D_2$	1.132	fghijk	32.	$S_4M_2I_2D_2$	1.144	defgh
13.	$S_2M_2I_1D_1$	1.148	cdefg	33.	$S_5M_1I_1D_1$	1.0343	t
14.	$S_2M_2I_1D_2$	1.157	bcde	34.	$S_5M_1I_1D_2$	1.066	rs
15.	$S_2M_2I_2D_1$	1.167	bcd	35.	$S_5M_1I_2D_1$	1.105	lmnop
16.	$S_2M_2I_2D_2$	1.174	b	36.	$S_5M_1I_2D_2$	1.1123	klmno
17.	$S_3M_1I_1D_1$	1.073	qrs	37.	$S_5M_2I_1D_1$	1.1107	klmno
18.	$S_3M_1I_1D_2$	1.135	efghijk	38.	$S_5M_2I_1D_2$	1.085	pqr
19.	$S_3M_1I_2D_1$	1.118	ijklmnb	39.	$S_5M_2I_2D_1$	1.093	opq
20.	$S_3M_1I_2D_2$	1.128	fghijkl	40.	$S_5M_2I_2D_2$	1.138	efghij

a, b, c,……. z; Indicates the significance levels of each treatment at ($P< 0.05$)

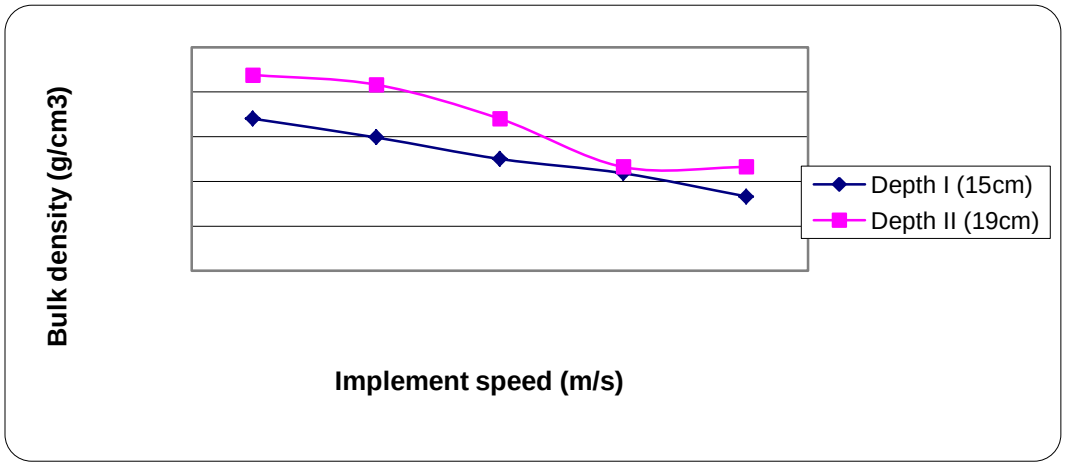


Figure 1(a): Influence of speed, tillage depth and moisture content on bulk density using disc plough at 6.58% db.

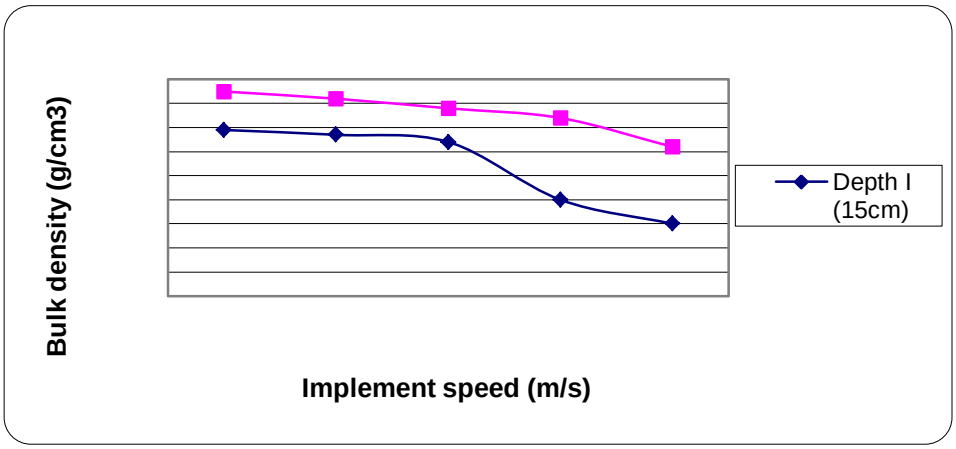


Figure 1(b): Influence of speed, tillage depth and moisture content on bulk density, using mouldboard plough at 6.58% d

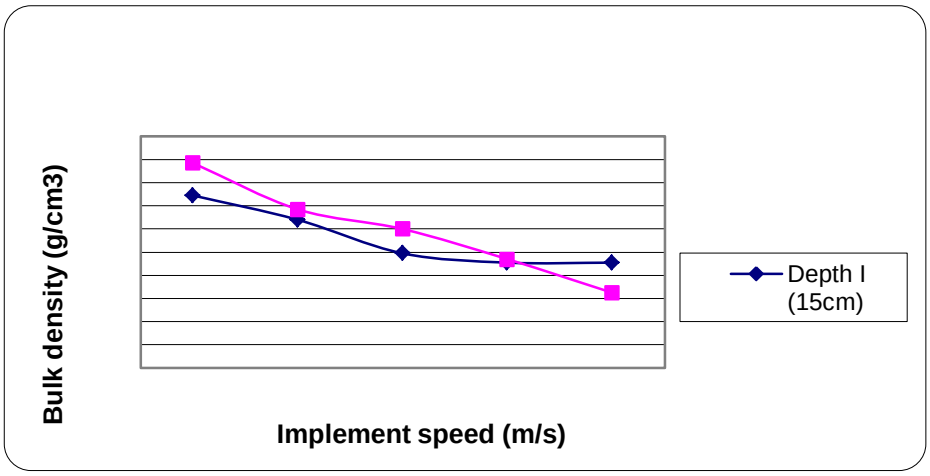


Figure 2(a): Influence of speed, tillage depth and moisture content on bulk density, using mouldboard plough at 10.47% db.

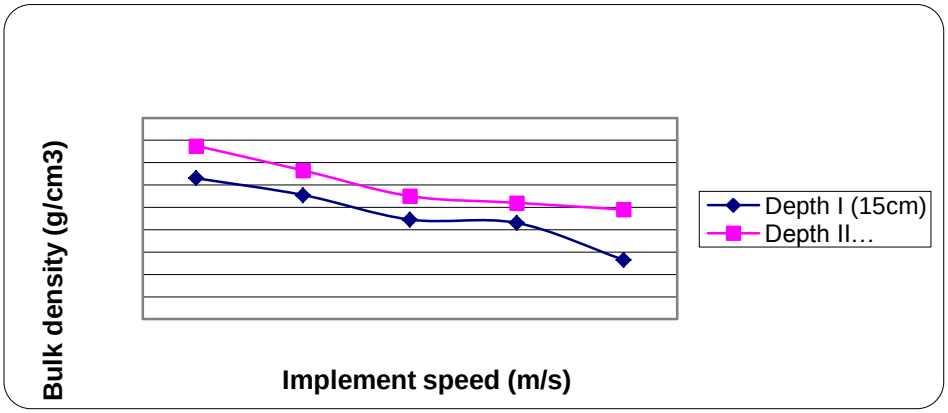


Figure 2(b): influence of speed, tillage depth and moisture content on bulk density using mouldboard plough at 10.47% db

CAPACITIVE PERFORMANCE STUDIES OF SELECTED TILLAGE OPERATIONS

Afolabi, A., Gwarzo, M. A. and Ohinoyi, F. G.

Department of Agricultural Engineering, Ahmadu Bello University, Zaria

ABSTRACT

Tillage operation are often time important for the general growth and yield of crops. The need for timeliness and effectiveness in tillage operations as well as increasing production necessitates the use of power units and implements. This study considers the capacitive performance and man-machine activity of three selected tillage operations. The plough was found to require a large traction to carry it out and that the actual width of tillage operation would determine the man-machine productivity.

1. Introduction

The drudgery involved in the use of hand tools in tillage and other agricultural activities call for the adoption of machinery in carrying out these activities. Besides, the needs for timeliness and precision in performing agricultural operations have also discouraged the primitive use of hand tools and manual labour in performing the operations. Not only does machinery perform faster but also can achieve a higher level of precision than hand tools. Machinery also requires less man-hour to carry out agricultural tasks than the manual labour.

However, before the mechanization of farming activities can be said to have been effectively adopted, there is the need for the proper investigation into the capacitive performance of the machinery involved. Also it is paramount to evaluate the suitability or otherwise of a machine in the environment in which it is to be used as well as the efficiency with which the task is performed by the machine; but without the knowledge of the capacitive performance of machines, it would not be possible to determine their field capacities and also their fields efficiencies (Ohinoyi 2011).

Researchers, scientists, academics and engineers have concentrated, focused and put much interest in the design, fabrication, construction and manufacture of agricultural machine so much that only a little interest is normally left for the managerial problems facing these machines. Although, the farmers, research institutes and machinery manufacturer require information on the capacitive performance of agricultural machines, this information, most of time, is not available. These have limited the proper adaptation of farm mechanization in Nigeria.It has therefore become necessary for proper performance evaluation to be carried out under different local conditions in order to have the required information on all available machines machinery system (Alabi2008).

This study entails the quantitative evaluation of the capacitive performance o f tillage implements on a tractor. It considers the theoretical and effective capacities and field efficiencies. The general objective of the study was to evaluate the capacitive performances and field efficiencies of some implements and power unit on tillage operations under field conditions. Specifically, the studies were aimed at determining the theoretical and effective field capacities; field efficiencies of the

tillage operations as well as to analyze the man-machine productivity, activity and performance during the selected tillage operations.

Although the first requirement of a machine is that it is able to perform its intended function(s) satisfactorily, the management aspect of the machine application is also of great importance (Kepner*etal* 1987). According to Kepner*etal*(1977), to work most effectively, researcher, academicians and engineers should have a thorough understanding of the factors affecting field capacities of operational field machines. The potential operating time of a machine may be categorized into two-the operational (functioning) time and the delay (stoppage) time. The delay time is the time during which loading and off-loading of machine may be done as well as the stoppage time to feed fertilizer, seeds etc and for the adjustment of equipment or a minor service of the machine. Delay activity begins when normal functioning of machine ceases and ends when the normal functioning resumes.

The theoretical field capacity of an implement is the rate of field coverage that would be obtained if the machine were performing its intended function 100% of the time at the rated forward speed and always covered 100%of its rated width. The effective field capacity is the actual average rate of coverage by machine and includes allowances for loss of time in servicing, turning, adjustment and failure to utilizethe full width of implement. Both theoretical and effective field capacities are measured in hectare per hour(ha/hr). Field efficiency is the ratio of effective field capacity to theoretical field capacity, expressed as a percentage. It is also defined as the percentage ratioof the functional time (the time during which an implement is actuallycarrying out its function) to the total field time.The field efficiency gives an accurate reflection of the effectiveness with which time is spent on the field(Alabi 2008).Gwarzo (1991) studied the capacities of Rome plough and disc harrow obtaining 2.34 ha/hr and 3.42 ha/hr. Hegot the field efficiencies of 97.23% and 93.74% respectively. Gwarzo used CAT D4E and CASE2590 tractors and operating speed 5.66 and 9.97 km/hrin the disc and harrow respectively.

Man-machine productivity is the ratio of the worked area to the total operational time excluding delay activitives, while man-machine activity is the percentageration of the operational time (excluding delay) to the total field time. Man-machine performance, expressed in hectare per hour, is the product of man-machine productivity and man-machine activities (where activities are expressed as decimal). The parameters show the indication of the effectiveness of man-machine in carrying out the assigned task.

2. METHODOLOGY

The investigations were carried out using a FIAT 640 tractor (48.5 kW) combined with either 0.484m integrally mounted disc plough, 1.68m offset disc harrow or 1.00m disc ridger for ploughing, harrowing and ridging operations respectively. The tractor operator was a 52-years-old man with above 20 years of experience in tractor operation. Each of the studied tillage operations was conducted in an area of 0.278ha. The total operation area for this study is 0.836ha.

The studies were carried out at the Institute for Agricultural Research (IAR)Samaru students' plot situated behind the National Agricultural Extension Research and Liaison Service (NAERLS) building at Ahmadu Bello University Zaria. The soil type is largely sandy-loam for the three plots, each of 149m by 18.7m, on which ploughing, harrowing and ridging were conducted respectively.

The time and motion study of each machine combination, while operating, were measured using accurate stopwatches to determine the activity time for the operations. The activity times were measured and recorded in field data sheets, specially prepared for the purpose, by an observers each at both end of the field. The end of a primary function activity was defined as the instant the power unit and implement reached the end of the field rowlength. The end of the turning activity and the beginning of the next primary function was defined as the instant the machine combination re-entered the next row completing the turn. A delay activity began the moment the forward motion of the machine combination ceased and ended the moment the forward motion resumed. The operational time is taken as the time for the primary functioning of the machine combine- that is- time of ploughing, harrowing or ridging and the support function time of turning. While delay time was taken as the time for idle travel, machine management stoppage and machine maintenance, when required. The other parameters measured include the field row length, the effective width of field operation, and the tillage depth for each of the operations as well as the soil type of the field. The soil analysis was carried out at the Department of Soil Science's laboratory of the Ahmadu Bello University, Zaria. The soil samples were taken from the field immediately after each of the field operations and the soil characteristics was determined in the laboratory. The soil characteristics determined were moisture content, bulk density, soil type and structure analysis.

All distances were measured using an accurate metre tape; except for the tillage depth of operation whichwas measured in centimetre using a special graduated measuring stick which was made topenetrate the tilled soil. The tillage depth was taken as the average of several depths determined along the row after each of the chosen tillage operations. In accordance to the recommendation of Barnes (1960), all field adjustments and machine services and/or maintenance operations that exceeded 10 minutes to execute were regard as a major breakdown and thus excluded from the delay activity time. The speed of operation for each set of machine combinations was measured in kilometre per hour. The tractor's speedometer was not used in the determination of the speed rather an average time to cover a marked out distance was measured and used in the determination of the speeds of each operation.

3. RESULTS AND DISCUSSION

A time study was carried out to obtain the capacitive performance of selected tillage operations. The time study information gathered for all the operation are given in Tables 1.1, 1.2 and 1.3 respectively for ploughing, harrowing and ridging operations. The observations were obtained for each operation and their average for the speed, turning, machine failure, management stop and the operation times as well as the total field time were obtained for each tillage operation.

Table 2 shows the depth of operations of each of the tillage operations carried out as well as the rated and effective width of the implements used for the operations in each of the operations above 80% of the rated width of each of the implements was actually utilised in the course of this study. These were found to be adequate enough to achieve a thorough coverage of the field while making optimal use of the power unit. Besides, the recommendations from literatures support the used width of the implements.

In tables 3.1, 3.2 and 3.3 the field performances of the FIAT 640 tractor and the implements for ploughing, harrowing and ridging operations respectively areshown. From the tables it can be

observed that the average speed for ploughing is the lowest among the selected tillage operations and that the mean traction speed during the operation ranged from 4.25 to 7.38 kilometres per hour. These speed ranges are in tandem with the speed reported by Gwarzo (1991) and also with the range recommended by ASAE (1988).

The theoretical field capacities for ploughing, harrowing and ridging are as reported in tables 3.1, 3.2 and 3.3. Again the theoretical field capacity of ploughing is the lowest. Thus, it can be observed that ploughing operation requires more traction force than the rest of the selected operations. This is reflected in its speed of operation and the theoretical efficiency of the tillage operations carried out for this study. Just as in theoretical efficiency, the effective field efficiencies of the operations are tabulated and it was found that ploughing has the lowest effective field efficiency. The reason is as stated above. The average effective efficiency of ploughing, harrowing and ridging are 0.3554, 0.75 and 0.91 hectare per hour respectively. The low value of effective field capacity of ploughing operation may be blame on the large amount of delay time for the management of the tractor which occur during the operation as well as on the large time spent in the turning in the course of the operation. The time spent in turning during the ploughing activity is largely due to the roughness and narrowness of the turning space and the presence of thick weed in the space.

The field efficiencies of the combination of FIAT 640 tractor and plough, harrower and ridger are also shown in tables 3.1, 3.2 and3.3 respectively. The field efficiency for ploughing is 79% that for harrowing is 75% and 77% for the ridging. Here it was found that the field efficiency of the plough has the highest value. This is because the plough requires a higher amount of energy and time to carry it out than all the other selected field operations. The time spent in ploughing a field is expected to be larger than the time spent in carrying out the other tillage operations if the forward speed, area and other factors remain constant. This is due to the fact that the rated and used width of the plough happened to be the smallest. Since as shown in table 2, the width of the ploughing implement is the smallest of the selected operations, it implies that more time would be required to cover the same area, if all other factors remain unchanged, than for the other two studied operations. This also indicates why a larger amount of time is used in ploughing than in those other operations and justifies the reason why the field efficiency of plough is the large. Literatures also give results which support the findings of the study.

The man-machine productivity was also computed for the combinations of the tractor and the plough, harrower and disc ridger individually. The respective values are as shown in columns E's of tables 3.1, 3.2and 3.3. Just as the capacity for plough has the smallest value in hectare per hour, so its man-machine productivity is quite low when compared the man-machine productivity of the other operations. This again may be attributed to the large support time spent in turning in the course of ploughing. The penultimate columns in the tables 3.1, 3.2 and 3.3 indicates the man-machine activity for ploughing, harrowing and ridging when combined with the said tractor. The columns show that the man-machine activity study is large and above 90%. These results reflect the competence of the machine operator and the effective engagement of the machine throughout the field time.

The final columns of the tables are the man-machine performances of the respective operations. The man-machine performances of the operations are reasonably good except in the case of the plough which is affected by the low value of its man-machine productivity. Since the man-

machine performance, determined usually in hectare per hour, is the product of man-machine productivity and the man-machine activity. It must be noted that the soil type of the studied field is largely sandy-loam.

4. CONCLUSION

It was found that amount the three selected tillage operations, ploughing requires the most tractive power for it operation and has the effective field capacity. It was found that the actual width used would affect the man-machine activity as well as the man-machine productivity in a combination of power unit and tillage implement.

REFERENCES

Alabi ,J.B (2008): Capacitive Performance Studies of Ploughing Operation in BirninKebbi.Annual Conference of Nigerian Institute of Agricultural Engineers, vol. 28p 113-116

ASAE (1988): Agricultural Engineers Handbook. St Joseph Michigan

Barnes K.k., (1960) Proper Evaluation of Machines. Implement and Tractors 75 (8):48

Gwarzo, M.A (1991): Capacitive Performance Study of Power and Machineries on Large Scale Farm. Unpublishes PhD Thesis, Department of Agricultural Engineering, Ahmadu Bello University, Zaria.

Kepner, R, A., Bialer, R and Berger, E.R (1977): Principles of Farm Machinery. AVI Publishing Co. Inc. West Port. Conn

Ohinnoyi G.F., (2011) Performance Evaluation of Selected Power Unit and Implements used in Tillage Operations. Unpublished Undergraduate Project, Department of Agricultural Engineering, Ahmadu Bello University, Zaria

Table 1.1 Results of time study of ploughing

Observations	Speed (km/hr)	Plough (min)	Turn(min)	Machine failure (min)	Management stop (min)	Total(min)
1	4.24	42.03	7.85	-	9.48	59.36
2	5.66	37.78	7.52	-	-	45.39
3	5.87	33.50	6.45	-	0.53	40.41
Mean	5.26	37.53	7.27	-	5.01	48.41

Table 1.2 Results of time study of harrowing

Observations	Speed (km/hr)	Plough (min)	Turn(min)	Machine failure (min)	Management stop (min)	Total(min)
1	6.51	17.85	4.65	-	1.07	23.57
2	7.38	15.75	4.67	-	1.22	21.64
3	6.91	16.82	4.50	-	-	21.32
Mean	6.93	16.81	4.61	-	1.15	22.18

Table 1.3 Results of time study of ridging

Observations	Speed (km/hr)	Plough (min)	Turn(min)	Machine failure (min)	Management stop (min)	Total(min)
1	5.05	14.13	3.97	-	0.7	18.80
2	5.80	13.83	4.20	-	-	17.58
3	5.65	14.23	4.63	-	-	18.86
Mean	5.50	14.06	4.27	-	0.7	18.41

Table 2.0 Widths of implements and depths of operations

Operation	Rated Width (m)	Actual Width Used (m)	Depth of Operation (cm)	Percent of Rated Width Used (%)
Ploughing	0.48	0.42	02	88
Harrowing	1.68	1.40	15	83
Ridging	1.00	0.92	28	92

Table 3.1 Capacity performance of tractor combined with plough

Observations	A	B	C	D	E	F	G
1	4.25	0.40	0.28	70.80	0.33	84.00	0.28
2	5.66	0.44	0.37	83.40	0.37	99.89	0.37
3	5.87	0.50	0.41	82.76	0.42	98.60	0.41
Mean	5.26	0.45	0.35	78.98	0.37	94.16	0.35

Table 3.2 Capacity performance of tractor combined with harrow

Observations	A	B	C	D	E	F	G
1	6.51	0.93	0.71	75.70	0.74	95.00	0.70
2	7.38	1.06	0.77	72.90	0.82	94.02	0.77
3	6.91	0.99	0.78	78.80	0.78	99.98	0.78
Mean	6.93	0.99	0.75	75.80	0.78	96.30	0.75

Key: A= speed, B= theoretical field capacity (ha/hr), C= effective field efficiency (ha/hr) D=field efficiency (%), E=man-machine productivity (ha/hr), F=man-machine activity (%) and G=man-machine performance.

Table 3.3 Capacity performance of tractor combined with ridger

Observations	A	B	C	D	E	F	G
1	5.05	1.18	0.88	75.00	0.92	96.04	0.88
2	5.80	1.21	0.95	78.50	0.93	99.98	0.93
3	5.65	1.16	0.89	76.40	0.89	9.98	0.89
Mean	5.50	1.18	0.91	76.63	0.91	98.67	0.90

MECHANIZATION OF FIELD OPERATIONS IN CASSAVA PRODUCTION: CHALLENGES AND PROSPECTS

M.C. Ikejiofor[1] and J.C. Adama[2]

[1]Engineering Research Unit, National Root Crops Research Institute, Umudike

[2]Dept. of Agricultural Engineering, Michael Okpara University of Agriculture, Umudike.mauikejiofor@yahoo.com

ABSTRACT

The need to mechanize cassava production field operations has long been felt worldwide. In Nigeria, with the demand for cassava both for food and industrial uses, mechanization of cassava field operations has become imperative if the huge demand is to be met locally. Also, for Nigeria to maintain the lead in global cassava production, urgent steps must be taken to mechanize all cassava production operations. Though numerous efforts have been made to develop suitable machines for the various cassava production operations, yet the mechanization problem of cassava production still remain unresolved due to the various challenges facing it. This paper presented the various challenges facing appropriate mechanization of cassava production operations and prospects. It also recommends various strategies that will promote effective mechanization of field operations in cassava production.

Keywords: Challenges, Mechanization, Field operations, Cassava, Production

1. Introduction

Cassava (Manihotesculenta Crantz) was introduced into Central Africa from South America in the sixteenth century by the early Portuguese explorers (Jones, 1959). It was probably the emancipated slaves who introduced the cassava crop into southern Nigeria, as they returned to the country from South America through the islands of Sao Tome and Fernando Po. At that time there were Portuguese colonies off Nigeria's shores (Ekandem, 1962). Cassava is one of the most important crops in Nigeria. It is the most widely cultivated crop in the southern part of the country in terms of area devoted to it and number of farmers growing it. Indeed, it is grown by almost every household.

The crop is important, not only as a food crop but even more so as a major source of income for rural households. It is largely consumed in many processed forms in Nigeria. Its use in the industry and livestock feed, is well known, and it is gradually increasing, especially as import substitution becomes prominent in the industrial sector of the economy. As a food crop, cassava has some inherent characteristics which make it attractive, especially to the smallholder farmers in Nigeria. First, it is rich in carbohydrates especially starch and consequently has a multiplicity of end uses. Secondly, it is available all year round, making it preferable to other more seasonal crops such as grains, beans and other crops for food security. Compared to grains, cassava is more tolerant of low soil fertility and more resistant to drought, pests and diseases. Furthermore, its roots are storable in the ground for months after they mature. These attributes combined with other socioeconomic considerations are therefore what International Fund for Agricultural Development (IFAD) has informed to recognized the crop as lending itself to a commodity-based approach to poverty alleviation (FAO/IC, 1995).

The growth in cassava production has been primarily due to rapid population growth, large internal market demand, complemented by the availability of high yielding improved varieties, a relatively well developed market access infrastructure, existence of improved processing technology and a well-organized internal market structure.

Cassava is produced largely by small-scale farmers using rudimentary implements. The average land-holding is less than two hectares and for most farmers; land and family labour remain the essential inputs (Nweke et al., 1997).

Almost all farmers in the main cassava belts of the southeastern, southwestern and central zones grow cassava, which is typically intercropped as a main or minor crop. Rotation and fallow systems are the traditional systems used by the farmers to maintain soil fertility but population pressure has resulted in reduced fallow, continuous cropping and reduced soil fertility. Farmers are generally aware of the benefit of inorganic fertilizer, but the commodity is scarce and a major constraint in cultivating improved varieties.

In Nigeria, with the demand for cassava both for food and industrial uses, mechanization of the field operations for the production has become imperative if the huge demand is to be met locally. The presidential initiative on cassava was aimed to create awareness among farmers on the opportunities in the cassava market world wide. It was targeted to produce 37.5 million tonnes of processed cassava products such as *gari*, pellets, chips, starch and ethanol annually for local and export markets. Nigeria's production of cassava increased from 32 million tonnes in 2000 to 45.72 million tonnes in 2006. The projected production target for cassava in Nigeria according to FAOSTAT (2009) is for the production to reach 62.82 million tonnes by 2025.

For Nigeria to maintain the leading producer of cassava, mechanization of its production which faces many challenges should be encouraged. The objective of this paper is to identify the various challenges that hinder the mechanization of cassava production and also recommend strategies for improvement.

2. TRENDS IN CASSAVA PRODUCTION

Cassava production in the country has been increasing for the past 30 or more years. A recent survey of the cassava-growing areas shows that in more than 90 percent of the 65 representative villages, the farmer group respondents reported an increasing trend in the production (Nweke*et al.*, 1997; Ugwu, 1996). Further analysis of the available production data shows that, on the average annual basis, the harvested land area was over 80 percent higher in 1990–1993 than in 1974–1977. Both the yield and of course, the overall production showed a similar trend. Total production from 1986 – 1996 is represented in (Table 1). Cassava also ranked first in terms of production among the major roots and tubers from 32million tonnes in 2000 to 45.72 million tonnes in 2006. There was a slight decline 43.4million tonnes in 2007, 53.87 million tonnes in 2008 and 36.8 million tonnes in 2009.

2.1. Mechanization of Cassava Production

Mechanization of cassava production involves use of mechanical assistance in various cassava production operations such as land clearing, planting, weeding and harvesting.

2.1.1. Land clearing

Mechanical land clearing involves three main operations: knockdown, windrowing and removal of debris using machines. The machinery used to accomplish the operations are the bulldozer, clearing rake, tree pushers, shearing blades, anchor chains, etc. These machines are mostly too complex and also very costly machines that are not within the reach of most farmers.

2.1.2. Planting

For mechanical planting, the cuttings used need to be uniform in length, size and shape. But, because of the variations in the size of cassava cuttings due to varietal differences. These seriously affect the development of an efficient cassava planter with stem cutting unit. The unavailability of the required quantity of cassava cuttings that can cover the hectare produced by the cassava planter is also a serious problem. Also the cultivars released for cultivation in Nigeria have not all been extended to farmers. Many released varieties are yet to be multiplied on a large scale and made available to farmers.

2.1.3. Weeding

The profused branchingpattern of most improved varieties of cassava also seriously affect the use of mechanical weeder from about 6 weeks after planting. This does not allow the weeder / operator to freely move along the rows. The branching pattern of some cassava varieties is represented in table 2 below.

2.1.4. Harvesting

There are variations between cultivars in root weight, depth of penetration, number of roots per stand and root length (Onochie, *et al* 1973). The rooting patterns of most existing improved cassava varieties do not allow easy mechanical harvesting. The mode of lateral and vertical (downward) spread of the roots in the soil is not well adapted to allow simple mechanical harvesting. To harvest the roots in their present form would require large machinery and still entail considerable crop losses. It is apparent that the form of the root system needs to be changed in order to have a plant type whose roots can be lifted easily with minimum of crop damage and loss.

2.2. Mechanization of Cassava Production Challenges

The challenges facing the mechanization of cassava production are numerous and include the following:

i. Mixed cropping
ii.Fragmented holdings

iii.Land degradation

iv.Poor capital base

v.Land tenure system

vi. Unavailability of improved and disease resistant varieties

vii.Unavailability of tractors for farmers

viii. Unique characteristics of cassava cuttings and roots

ix.Lack of subsidies on fertilizers and other agro -chemicals

x.Inadequate market opportunities at both domestic and international levels, and also

poor feeder roads linking cassava farms and processing centers

xi. Lack of awareness of the existence of the technologies by farmers

xii. Poor credit facilities

xiii. Lack of suitability of several of the existing equipment to meet farmers' exact requirement and production environment

xiv. Lack of trained machinery operators and skilled village artisans to service and repair the equipment when they break down

xv. Inadequate repair and maintenance facilities as well as difficulties in obtaining spare parts for machines and equipments

2.2.1. Mixed cropping

Cassava adapts to a wide range of ecological conditions and is known for its tolerance to low soil fertility, drought and pests. This is why the plant continues to hold an important position in traditional tropical cropping systems, particularly in those of the small – farm and subsistence sectors. In these cropping systems cassava is often found in mixed stands together with other food and cash crops. Traditional farmers adapt intercropping as a production system in order to reduce the risk of crop failure, and make the best use of the available land and labour resources. However, this practice does not encourage mechanization of especially the weeding operation in the cassava production. Recent estimates indicate that 40 and 50% (or more) respectively of the cassava grown in America and Africa is intercropped (Dietrich Leihner, 2000). The table3 below shows the cassava cropping pattern, which indicates that cassava is grown mainly as an intercropped and sometimes as a sole crop and that it can be a main crop as well as a minor intercrop.

2.2.2. Fragmented holdings

Generally, most of the farmers are smallholders with production primarily oriented towards meeting subsistence needs. They hold about 90 percent of the land and produce more than 90 percent of the agricultural commodities; large-scale farmers account for less than 10 percent of agricultural production. Average cultivated area per farming household ranges from 0.3 ha in the south to 2.5 ha in the central zone (Middle Belt). Many farmers have small land holdings which are scattered in different locations. Ali El Hossay (1988) confirmed that land fragmentation with numerous canals and drainage ditches, narrow access roads to individual farm plots; seriously restrict the use of mechanized equipment.According to Apu, 2006 who reported of the survey result on land resource allocation to various crops grown in Abia state which revealed that the

mean area planted per farmer for the TMS 30572 and NR 8082 cassava varieties were only 0.36 and 0.3ha respectively as presented in table 4 below.

2.2.3. Land degradation

Due to heavy rainfall, there is serious erosion which washes away top soil. The soil is generally acidic and the fertility is low. The farmer will spend heavily to remedy the low soil fertility if he is to invest and make gain in mechanized farming. In many instances, floods submerge farmlands and destroy crops completely. Farmers incur irreparable losses especially as they do not have farm insurance. In the coastal areas, there are often, cases of oil spill which destroy hectares of farms and bring heavy losses to farmers. Also, because of gas flaring in some areas, the rains which fall are acidic and this adversely affects soil fertility.

2.2.4. Poor capital base

Most farmers have no capital to invest in farming. At harvests, they sell their farm products and make use of the money realized. During the next planting season, they have no money to hire machinery and also buy farm inputs. Many of them have no collaterals for credit facilities.

2.2.5. Land tenure system

In many communities, land is inherited and outright sale is forbidden. Investors may not be able to buy land to large scale cassava farmers which can be mechanized. Also, women who constitute about 75% of cassava farmers do not own land in many communities, and since land is invested in men, these women do not have power to merge their individual little plots to favour farm mechanization.

2.2.6. Unavailability of improved and disease resistant cassava varieties

Most farmers do not have access to the high yielding and disease resistant varieties. Majority of these improved cassava varieties are still very scarce and there is need for their multiplication to make them fully available to farmers.

2.2.7. Unavailability of tractors to farmers

Governments at the national, state and LGA levels, have attempted to ease the labour constraint problem and stimulate expansion of farms through tractor-hiring services but the tractors are either inaccessible to the poor who need them most or in a state of disrepair. In view of the high cost of tractors and their likely decline in availability, their use by poor farmers is almost out of the question.

2.2.8. Unique characteristics of cassava cuttings and roots

Cassava cuttings have very unique features that make them extremely difficult to handle as planting materials. The cuttings vary widely among and within varieties in terms of size, girth, straightness, the shape of the cross section and the number of nodes per unit length. The plantable diameters of cuttings vary randomly between 10mm or less and 50mm or more. Also, the presence of nodes scattered on the surface make the design of metering mechanism for the cuttings very difficult. Also, cassava has no specific harvesting season. Therefore, the cassava harvester must be able to work well in the parched hard soils of the dry season, the drenched /

muddy soils of the rainy season. Cassava has 3 – 8 roots per plant which weigh together 1 – 6kg and which develop at a depth of 150 – 450mm, with a radius of spread of 100 – 250mm. To accommodate the random growth pattern of the roots, the harvesters has to handle about $0.25m^3$ of soil per meter length of ridge to dig and lift the roots. Due to these unique characteristics of the cassava crop, the very considerable worldwide R&D efforts to develop a cassava harvester have not yielded one that is generally acceptable (Odigboh, 2006).

2.3. Prospects of Mechanization of Field Operations in Cassava Production

In Nigeria, with the demand for cassava both for food and industrial uses, mechanization of cassava field operations is very essential. The presidential initiative on cassava aimed to create awareness among farmers on the opportunities in the cassava market world wide. It was targeted to produce 37.5 million tonnes of processed cassava products such as *gari*, pellets, chips, starch and ethanol annually for local and export markets. Nigeria's production of cassava increased from 32 million tonnes in 2000 to 45.72 million tonnes in 2006. The projected production target for cassava in Nigeria according to FAOSTAT (2009) is for the production to reach 62.82 million tonnes by 2025. Mechanization of cassava field operations is the main strategy for Nigeriato achieve the projected production target and also maintain the world leading producer of cassava.

3. Strategies To Effective Mechanization Of Cassava Production

Consequently, future intervention strategies should include the following:

1. Collaborative work among all the stakeholders in cassava production including the farmers, the agronomists / scientists, the design engineers, tuber processors, research institutes, universities and the government should be encouraged.
2. The development of simple indigenous machines for the various operations in cassava production should be encouraged to meet exact farmers need and environmental conditions.
3. The agronomists (breeders) should come out with improved varieties suitable for mechanized harvesting, such as varieties with predictable shape, geometry, depth and spread of growth in the soil.
4. The design engineers should start from fundamental principles to generate adequate design data for the development of cassava production machines.
5. Research institutes, educational institutions and government establishments should be empowered by international donors to develop machines for cassava production.
6. Farmers should be encouraged to come together and form cooperatives so as to attract credit facilities and farm inputs from government. The cooperatives will also be able to acquire farm equipment for mechanized farm.
7. Development, rapid multiplication and dissemination of improved varieties to enhance the availability and diversity of improved planting materials. The use of existing and new cultivars should be made popular through an extended or expanded cassava multiplication programme. Generating more varieties while not extending those already available to farmers is not good enough.
8. Funding support for various levels of research at the NRCRI and among other scientists working on cassava should be substantially increased so as to close gaps in the knowledge of the crop.
9. More research is needed to develop appropriate post-harvest technologies that are cost-effective, easy to fabricate, have appropriate designs and are easy too operate and

maintain at the farm level. Above all, as much as possible, such technologies should not be based on electrical or petroleum sources of energy.

10. Middlepersons should be encouraged to actively participate in marketing cassava by improving market access. If properly "energized", ADPs can build feeder roads and substantially improve access to markets.

4. CONCLUSION

For Nigeria to maintain the lead in global cassava production, intensive mechanization of all the cassava production field operations should be encouraged. There is serious need for the development of simple indigenous machines for the various operations in cassava production to meet the exact farmers' need and environmental conditions. However, if breeders can come up with the improved varieties suitable for easy mechanical harvesting, and also the other specified strategies implemented, then there is serious hope that mechanization problems of cassava production in Nigeria will be solved in the nearest future.

REFERENCES

Ali El. Hossay. 1988. Mechanized Rice Production in Small Holdings, the Egyptian Experience. Proceedings of C.I.G.R. Inter – Sections Symposium / Nigerian Society of Agricultural Engineers held at the National Centre for Agricultural Mechanization, Ilorin, Nigeria. September 5 – 10.

Apu, U. 2006. Evaluation of Land Resource Allocation to Cassava Cultivation in Abia State, Nigeria. Proceedings of the 40th Conference of the Agricultural Society of Nigeria held at National Root Crops Research Institute, Umudike. October 16 – 20. Pg. 94.

Dietrich, L. 2000. Management and Evaluation of Intercropping Systems with Cassava.Centro International de Agricultura Tropical, Cali, Colombia.Pg.70.

Ekandem, M.J. 1962. Cassava in Nigeria: Eastern Nigeria. Federal Department of Agricultural Research Memo No. 42. Ibadan, Nigeria.

FAO/IC. 1995. Formulation Reports: Root and Tubers Expansion Programme, FAO, Rome, Italy.

FAOSTAT, 2009.The Food and Agricultural Organisation Data Base Results.Assesssed June, 2011.

FMANR, 1997.Nigeria Agricultural Statistics (Time Series Data).Department of Planning, Research and Statistics, Abuja, Nigeria.

Jones, W. O. 1959. Manioc in Africa.Stanford University Press. Stanford. USA.

Nweke, F.I.; Ugwu, B.O.; Dixon, A.G.O.; Asadu, C.L.A. and Ajodo, O. 1997.Cassava Production in Nigeria.A Function of Farmer Access to Market and to Improved Production and Processing Technologies.COSCA Working Paper, No. 21.Collaborative Study of Cassava in Africa. International Institute of Tropical Agriculture , Ibadan., Nigeria.

Odigboh, E.U. 2006. Engineering Aspects Neglected in the New National Initiative on Cassava Production and Processing. Agro Industrial Raw Materials Processing for Sustainable Development of South East Nigeria.Proceedings of a Forum on Refocusing Agro Industrial Raw Materials Processing in the South East Zone of Nigeria, organized by the Nigerian Institution of Agricultural Engineers. Pg 35 – 47.

Onochie, B.E.; Makanjuola, G.A and Schulte. 1973. Mechanization of Cassava Production. A Study to Determine the Suitability of Present Cassava Cultivars for MechanicalHarvesting.www.istrc.org/sites/default/files/files/symposium/internal/1973_Nigeria/3rd_symposium_proceedings_46.pdf

Ugwu, B.O. 1996. Increasing Cassava Production in Nigeria and Prospects for Sustaining the Trend.Outlook on Agriculture Vol. 25, No.3.Pg 179 – 185.

Table 1. Estimates of annual area cultivated, root yields and total output for cassava in Nigeria during 1986–1996

	1 000 ha cultivated	**Yield tonne/ha**	**Output '000 tonne**
1986	1 095	11.3	12 388
1987	1288	10.8	13 876
1988	1347	11.5	15 540
1989	1371	12.7	17 404
1990	1 472	12.9	19 043
1991	2 551	10.2	26 004
1992	2 755	10.6	29 184
1993	2 844	10.6	30 178
1994	2 927	10.6	31005
1995	2 944	10.7	31404
1996	2 546	10.7	31448

Source: FMANR (1997)

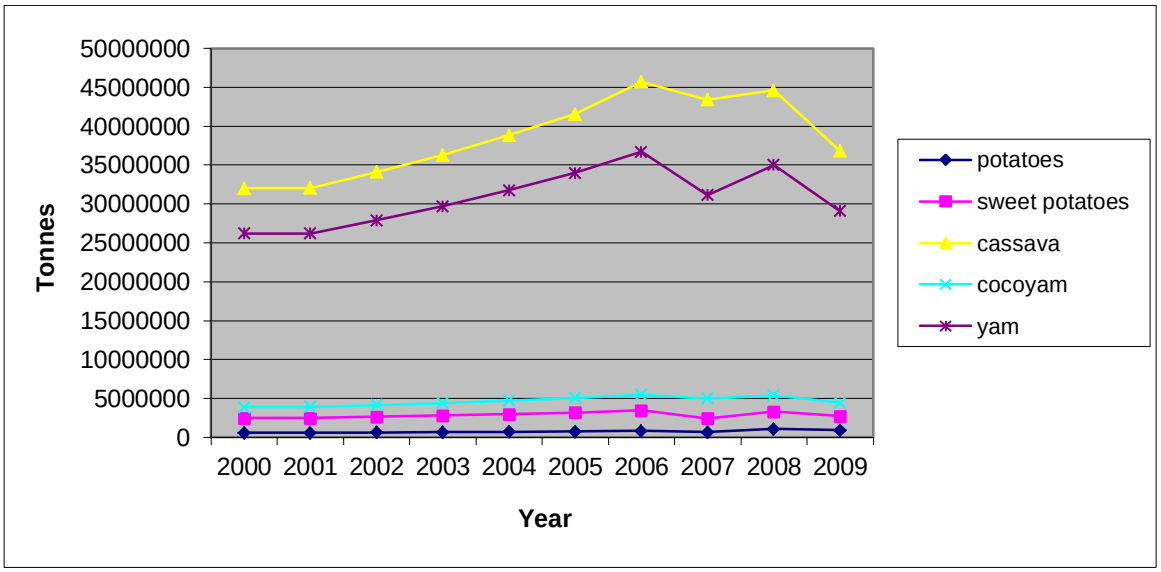


Fig. 1: Production (tonnes) of Roots and Tubers by Commodity, 2000-2009

Source: Basic data from FAO 2009 (FAOSTAT June 2009, accessed June 2011).

Table2. Attributes of the seventeen cassava varieties released for cultivation in Nigeria

Cassava variety	**Branching habit**	**Canopy development**	**Ecological adaptation**	**Pest and disease tolerance**	**Fresh root yield (tonnes/ha)**	**Dry matter yield (80 C24h)**	***Gari*yield(%)**	**Starch yield (%)**	**HCN in products (mg 100g)**
TMS 90257	profuse	moderate	wide	high	43	25	23	23	15.5
TMS 84537	moderate	sparse	wide	high	35	28	18	27	6.3
TMS 82/00058	profuse	moderate	wide	high	35	28	21	26	6.4
TMS 82/00661	profuse	moderate	wide	high	39	30		26	4.1
NR8212	profuse	moderate	wide	high	27	37	25	21	high
NR 8082	profuse	profuse	wide	high	32	32	22	19	high
TMS 50395	moderate	moderate	wide	moderate	36	29	24	12	high
TMS 30001	moderate	moderate	wide	moderate	16	28	23	22	low
NR 8208	profuse	moderate	wide	moderate	26	32	25	23	high
NR 8083	profuse	moderate	wide	high	31	43	36	25	high
NR 83107	profuse	moderate	wide	high	22	31	22	19	high
TMS 8 1/00110	profuse	moderate	wide	high	28	31	24	25	4.5
TMS 91934	moderate	sparse	wide	moderate	32	34	26	21	high
TMS 30572	profuse	profuse	wide	moderate	27	34	25	24	750
TMS 4(2)1425	moderate	profuse	savanna moderate		26	36	25	22	31
TMS 30555	moderate	profuse	wide	moderate	17	32	24	20	high
NR 41044	moderate	profuse	forest	moderate	37	34	25	23	high

The HCN content of the products was determined quantitatively by the enzymic method. Where this was not available, it was determined by the picrate leaf method and therefore reported as either high or low.

Table3. Percentage distribution of crop fields by cropping pattern

Crop	**No. of fields**	**Sole**	**Major**	**Minor**	**Total**
Cassava	494	36	38	26	100
Yam	163	13	79	8	100
Maize	306	9	13	78	100
Rice	34	82	6	12	100
Sorghum/millet	100	19	41	40	100
Beans/peas	92	20	10	70	100
All crops	1 189	25	35	41	100

Source: Nweke et al. (1997)

Table 4: Total Land Area (ha) Planted to Improved Cassava Varieties

Cassava Varieties	**TMS 30572**	**NR 8082**
No. of Plots	248	302
Land area (ha)		86
Mean Land Area (ha)	0.36	0.3
Total Farm holdings (ha)	225	
CassavaLand area (ha)	175.8	

Source: Field Survey (Apu, 2006)

EFFECTS OF SELECTED FACTORS ON PERFORMANCE OF A MOTORIZED MILLET THRESHER

Abubakar, L.G.[1] and Abdulsalam, M.[2]

[1]Agricultural and Bio-Resource Engineering Programme,
AbubakarTafawaBalewa University, Bauchi.
[2]Agricultural Engineering Department, Ahmadu Bello University,
Zaria.daniyasalam@yahoo.co.uk

ABSTRACT

The performance of an existing stationary thresher was evaluated at different levels of cylinder speed (700 rpm, 600 rpm and 500 rpm), grain moisture content (12%, 10% and 8%)and feed rate(3 kg/min, 2kg/min and 1kg/min). Both threshing and cleaning efficiencies increased with increasing speed and reducing moisture content.As high as 99.1% threshing efficiency, 99.5% cleaning efficiency, 96 kg/hr equipment throughput, 5% grain damage and 6.9% scatter losses were obtained at 700 rpm cylinder speed, 8% product moisture content, and 1 kg/hr product feed rate.

Keywords:Millet, Thresher, performance, moisture content, speed

1. Introduction

Millet is an important crop in northern part of Nigeria and considered as a staple food. Among the varieties of this crop; pennisetumtyphoides, pennisetummaiwa and pennisetumdauro are widely grown (Abalu, 1978). Threshing is one of the most important and earliest post-harvest operations. Millet threshing improves the quality and ensures maximum utility of this important crop (IAR, 1987). An integrated threshing operation involves the detachment of the grains (kernel) from the stalk and separation of grains and chaff. Threshing of grain crop from stalk is mainly by impart, rubbing and squeezing, crushing or shattering and these actions occurs simultaneously (Singh and Joshi 1976). Proper measures need to be taken as to optimize the threshing process by using lesser energy to accomplish the desired process (threshing). Optimum threshing operation entails adequate detachment of grains from the stalk, little or no mechanical damage on the grains, minimized scatter loss and grain should be properly cleaned (Hunt, 1983). Dash (1989) reported that thresher performance largely depends on the moisture content of the crop. At high moisture content (21 % and above), the power required to detach grains is higher, consequently more breakage and poor threshing efficiency. He further reported that the cylinder speed is also one of the factors that affect threshing efficiency and mechanical grain damage.

Joshi (1981) evaluated the impart damage to grains as a result of high speed collision with a steel plate. They concluded that damage on seeds is dependent on both seed moisture content and the velocity of impart. Hunt (1983), after his studies concluded that moisture content at which threshing is carried out, concave-drum clearance and pitch of screw are all factors that affect threshing. In addition, Kepner et al (1992) reported that four variables are very important when threshing is considered, these factors includes the peripheral speed of the cylinder, the clearance between the cylinder and concave, crop maturity and the feed rate.

Joshi (1981) stipulated that physical parameters affecting the cleaning process of a thresher includes all the machine factors (sieve oscillation, amplitude of oscillation, sieve slope, length of

sieve, width of sieve and sieve hole diameter) and the crop factors (crop varieties, maturity stage, grain moisture content, straw moisture content, bulk density of grain, bulk density of straw, stalk length, grain diameters and angle of repose).Phillip and Callaghan (1974) are of the view that the efficiency of both primary and secondary grain/straw separation are reduced with increasing moisture content, that is as the surface of straw become damp, the coefficient of straw-metal friction increases, causing transport problems. Simonyan et al (2006) reported that increase in moisture content leads to more adhesiveness between the grain and other constituents to be separated. They added that increase in cylinder speed result in an increase range of particles sizes and formation of minute particles, which aerodynamically resembles millet grains there by creating challenges in cleaning operation. Most pronounced factors influencing the performance of a thresher are the feed rate, cylinder speed and moisture content of the crop (millet). Generally, threshers are evaluated using the well-known indices; threshing efficiency, mechanical visible damage on grains, cleaning efficiency, scatter loss and grain throughput capacity. These five parameters were used as performance indicator in this study.The objectives of this study was to determine the effect of cylinder speed, grain (millet) moisture content and feed rate on the performance of a motorized millet thresher.

2. MATERIALS AND METHOD

2.1. Materials

A common millet (*Pennisetumtypoides*) locally known as 'gero' was selected and used for this study.

2.2. Methods

Determination of crop (millet) moisture content

The moisture contents of the grains were determined on wet basis. The samples collected were air dried, placed in a container and oven dried. Moisture contents were determined as:

$$M_{ci} = \frac{w_i - w_d}{w_d} \times 100$$

Where;
i=1, 2, or 3
M_{ct}= moisture content (%)
w_i =initial mass of sample (g)
w_d= final mass of sample (g)

2.3. Experimental procedure

Three factors were considered for this study, namely cylinder speed, moisture content and feed rate. Each was evaluated at three levels, namely 700 rpm, 600 rpm, and 500 rpm cylinder speed, 12 %, 10 % and 8 % moisture contents and 1, 2 and 3 kg/min product feed rates. This constituted 27 treatments, fitting a completely randomized design. The performance indices were evaluated as follows:

Threshing efficiency, Eth

$$E_{th} = 100 - \frac{M_u}{M_t} \times 100\ \%$$

Where, E_{th}=threshing efficiency %
M_u=mass of un-threshed grain in sample (kg)
M_t= total mass of grain sample (kg)

Visible Mechanical Grain Damage,M_{gd}

$$M_{gd} = \frac{M_b}{M_t} \times 100\ \%$$ (ASAE, 1984)

Where, M_b= mass of broken grain in sample kg
M_t= total mass of grain in sample kg

Cleaning efficiency E_c

$$E_c = \frac{M_{cg} - M_c}{M_{cg}} \times 100\ \%$$

Where, M_{cg}= mass of total mixture of grain and chaff received at the main outlet (kg)
M_c= mass of chaff at the main outlet of the thresher (kg)
E_c = cleaning efficiency %.

Scatter loss L_s (%)

$$L_s = \frac{M_L}{M_t} \times 100\ \%$$

Where, M_L= mass of grans scattered around the machine after threshing operation (kg).
M_t = total mass of grain in sample (kg).

Grain throughput capacity, G_c (kg/hr)

$$G_c = \frac{M_s}{t} \times 60\ (\text{kg/hr})$$ (Kebede and Mishara, 1990)

Where, M_s = mass of threshed grain collected after a threshing operation (kg)
t = time taken for a complete threshing operation (min).

3. RESULTS AND DISCUSSION

Results of performance evaluation tests conducted are presented on tables 1 – 4.

3.1. Effect of cylinder speeds

Results of the effects of speed on threshing performance are shown in Tables 1 and 2. Cylinder speed had a positive association with threshing efficiency, being 94% at 500 rpm and 98% at 700rpm. As high as 99% threshing efficiency was recorded at 700rpm cylinder speed, 8% moisture content and 1kg/hr product feed rate.

3.2. Effect of moisture content

Effect of moisture content on thresher performance are shown on Tables 1 and 3. At 12% moisture content the equipment had a mean threshing efficiency of 85.44%. Mean threshing efficiency increased with reduction in moisture content. As high as 97.3% threshing efficiency was recorded at 8% moisture content. Cleaning efficiency reduced with increasing moisture content. Cleaning efficiency was 87.5% at 12% moisture content and 95% at 8% moisture content. As low as 3.22% grain damage was incurred at the highest moisture content. Mean grain loss increased with reductions in moisture content level.

3.3. Effect of feed rates

Results of the effects of product feed rate on performance indices are shown in Tables 1 and 4. Threshing efficiencies recorded within the 1 – 3 kg/hr feed range were between 95 – 97%. Mean cleaning efficiencies within this range were 89 – 91%. Grain damages of between 3 – 4% were recorded within the same product feed range while scatter losses within this range was between 5 – 6%.

4. CONCLUSION

The research presents the influences of cylinder speeds, grain moisture content and feed rates on the performance of a millet thresher. The highest threshing efficiency 99.1%, cleaning efficiency 99.5 % and through put capacity 96 kg/hr were obtained at the highest selected cylinder speed 700 rpm, at the selected least grain moisture content (8%) and 1 kg/hr feed rate. Finally, at this combination of the considered factors, the best performance of the millet thresher was obtained.

REFERENCES

Abalu, G.O.I. (1978). The food situation in Nigeria: An economic analysis of Millet and Sorghum. Samaru Miscellaneous paper 80 I.A.R, Ahmadu Bello University, Zaria, Nigeria.

American Society of Agricultural Engineers, (1984).Moisture measurement- grain and seeds. ASAE standard, American Society of Agricultural Engineers, 352: 384-385.

Dash, S. K. and Dash, D. K. (1989).Development of a power operated paddy thresher; Agricultural Mechanization in Asia, Africa and Latin America, vol. 20 No. 37-40.

Hunt, D. (1983). Farm power and machinery management. 8th edition Iowa State University press USA. Pp 30.

Institute for Argicultural Research (1987). A report on Agricultural Engineering Prototypes. Agricultural mechanization research programmed, Ahmadu Bello University, Zaria.

Joshi, H. C. (1981). Design and selection of thresher parameter and components, Agricultural Mechanization in Asia, Africa and Latin America. 6(2): 61-68

Kepner, R. A., R. Baines and E. L. Barger (1978).The principles of farm machinery.Second edition. The AVI publishing company Inc. USA: Pp. 87-88

Kebede, D. and T. N. Mishra (1990). Development and performance evaluation of sorghum thresher: Agricultural Mechanizatoion in Asia. 21(3): 33-37.

Philip P. R and J.R.O Callaghan (1977). Cereal harvesting- a mathematical model. Journal of Agricultural Engineeering Research 19:415-417.

Singh, K. L and H. C. Joshi (1977). Design and development of rice culture machinery for different power sources, progress report fro AD-Hoc ICAR research project. Agricultural Engineering Department, GB pant University of Agriculture and Technology Pantnager.

Simonyan, K. J, Y. D, Yilyep and O. J, Mudiare (2006): Modeling the cleaning process of a stationary sorghum thresher. Agricultural Engineering International: The CIGRE Journal, 8:1-17

Table 1: performance of the millet thresher at different treatment

Factors	**level**	**Threshing efficiency %**			**Cleaning efficiency %**			**Mechanical grain damage %**			**Scatter loss %**			**Through put capacity kg/hr**		
		M1F1	**M2F2**	**M3F3**	**M1F1**	**M2F2**	**M3F3**	**M1F1**	**M2F2**	**M3F3**	**M1F1**	**M2F2**	**M3F3**	**M1F1**	**M2F2**	**M3F3**
Speed S_i rpm	700	97.2	98.7	**99.1**	87.2	92.3	99.51	4.1	4.21	5.09	7.1	6.7	6.91	69	78	96
	600	95.40	96.6	97.1	86.9	910	98.1	3.5	4.2	5.0	5.17	5.3	6	53.6	59	62
	500	92.1	93.5	95.9	84.7	88.7	92.7	2.1	3.91	4.22	5.0	4.98	4.96	49.2	53	59
		S1F3	**S2F2**	**S3F1**	**S1F3**	**S2F2**	**S3F1**	**S1F3**	**S2F2**	**S3F1**	**SF13**	**S2F2**	**S3F1**	**S1F3**	**S2F2**	**S3F1**
Moisture M %	12	82.53	**81.7**	92.1	90.1	87.6	84.7	3.57	4.0	2.1	5.5	4.89	4.19	62	42	49.2
	10	92.71	91.60	93	92.5	91.0	86.8	4.87	4.2	3.97	6.5	5.3	5.1	71.1	59	62
	8	99.1	97.1	95.6	99.51	94.1	89.5	5.09	5.17	3.99	6.91	6.3	6.98	**96**	75	72
		S3M3	**S1M1**	**S2M2**	**S3M3**	**S1M1**	**S2M2**	**S3M3**	**S1M1**	**S2M2**	**S3M3**	**S1M1**	**S2M2**	**S3M3**	**S1M1**	**S2M2**
Feed rates kg/min F	3	91.81	97.2	94.7	90.1	87.2	89.2	3.99	2.75	3.11	6.98	4.01	4.91	72	78	43.5
	2	93.95	97.83	96.6	91.2	87.3	91	4.01	3.01	4.2	7.0	4.28	5.3	81	90	59
	1	95.9	98.1	96.9	92.7	88.1	92.7	4.13	3.57	4.51	7.3	5.51	6.25	92	96	73

Table 2: average performance of the millet thresher at variable speed

Variable speed, rpm S	Average threshing efficiency %	Average cleaning efficiency %	Average mechanical grain damage %	Average grain loss %	Average through put capacity kg/hr
700	98.33	93	4.47	6.9	81
600	96.37	92	4.23	5.49	54.90
500	93.83	88.7	3.41	4.98	53.73

Table 3: average performance of the millet thresher at variable moisture contents

Variable moisture, % M	Average threshing efficiency %	Average cleaning efficiency %	Average mechanical grain damage %	Average grain loss %	Average through put capacity kg/hr
12	85.44	87.5	3.22	4.86	51.07
10	92.44	90.1	4.08	5.63	64.03
8	97.27	94.37	4.75	6.73	81

Table 4: average performance of the millet thresher at variable feed rates.

Variable feed rates, kg/min F	Average threshing efficiency %	Average cleaning efficiency %	Average mechanical grain damage %	Average grain loss %	Average through put capacity kg/hr
3	94.57	88.83	3.28	5.30	64.50
2	96.13	89.83	3.74	5.53	76.67
1	96.97	91.17	4.07	6.35	87.0

ESTIMATION OF SUITABLE FIELDWORK DAYSFOR PLANTING AND HARVESTING OPERATIONS OF MAIZE PRODUCTION IN BAUCHI LGA

Jahun, B. G.[1], Iya, S. A.[2] and Abubakar Y.[3]

[1]Dept of Agricultural and Bio-resources Engineering, ATBU Bauchi
[2]Dept of Agricultural and Environmental Engineering, MAUTECH, Yola
[3]Dept of Agricultural Engineering, Federal Polytechnic, Mubi

ABSTRACT

The atmospheric weather condition especially the amount of rainfall and the soil moisture content are two factors which dictate the suitability or non-suitability of a day for fieldwork. Agriculture is limited by weather variation with season and timeliness cost would be increased if the operations are not performed promptly. It becomes important therefore for the estimation of suitable fieldwork days during which operation are carried out at minimum cost and no damages to the soil. This study looked at the availability of fieldwork day and would serve as a guide for the proper scheduling and selection of the optimum machinery capacity for agricultural task which will have the lowest production cost but produce the best yield. The average number of good field workdays of the ten years farming seasons was 40 days and the average number of best tillage workdays for the ten years was found to be 22 days

Keywords:Workability, tractability, trafficability, fieldwork

1. Introduction

Soil moisture content and the weather are the two major factors which determine the amount of time available throughout the year for field operations (Whitney, 1988). In a poor season, limited time may be available for performing one or several field operations under acceptable conditions. On the other hand, a favorable season and firm soil, provide abundant time in which the field work can be completed without working excessively long hours at a time, or working in unsatisfactory conditions.

The weather interacts with the soil to vary soil workability for tillage operations and with the crop to vary yield and moisture content at maturity for harvesting operations, thus the influence of the weather on soil tractability affects all operations to a greater or lesser extent. Therefore the workability and trafficability of the soil is dependent on the soil moisture content which can be evaluated from soil and weather variable (Whitney, 1988).Provided that all the relevant factors can be obtained for the soil and the crop, suitable workdays can be identified. As a preliminary stage, commonly accepted operational windows are used to provide workday data for strategic planning purposes. It is the airm for this research study to look at best days in the season to plant maize as well as the optimum time for its harvesting. It also determined the best tillage workdays for the study area.

2. METHODOLOGY

Climatic Data

Climatological information that are required for the estimation of suitable workdays include complete daily records of relative humidity, air temperatures (maximum, minimum) and rainfall

records.The procedure for the estimation of suitable field workdays was made in three main stages as follows:

(i) Obtaining the weather data or Climatological information for the area. Weather data for Bauchi area was collected from the weather records office of the Federal Ministry of Aviation, Bauchi.

(ii) Soil moisture content for the field was selected as a variable to describe soil condition for tractability. Computation of daily change in soil moisture for the period of the year beginning in May and ending in October was made using equation 1.

(iii) Thesuitability of a workday based on data from literature and soil sample analysis were established using the soil moisture budget method. The established criteria were used with the soil moisture budget to differentiate between a "tractable" (workable) and a "non-tractable" (non-workable) soil condition.

2.1. The Soil Moisture Budget

Information on potential evapotranspiration, actual evapotranspiration, rainfall, runoff and drainage were required for the SMB. The commonest SMB consists of subtracting daily potential evapotranspiration from daily rainfall.This amount is then subtracted (or added when rain exceeds potential evapotranspiration) from moisture present in the soil to give the new soil moisture storage. A simple soil moisture balance relationship as suggested by Babeir et al., (1986) was adapted for the SMB. The relationship is expressed as Equation 1 below:

$$DSM = R_a - E_{ta} - R_o - D_p \quad \ldots (1)$$

Where,

DSM = daily change in soil moisture, mm

Ra = amount of rainfall for the day, mm

Eta = daily actual evapotranspiration mm day $^{-1}$

Ro = amount of run off for the day, mm

Dp = deep percolation.

2.2. Daily Potential Evapotranspiration

Evapotranspiration has been defined as the combined loss of water from a given area by evaporation from the soil surface and by transpiration from plants. When there is sufficient moisture in the soil, the amount of evapotranspiration required to satisfy the atmospheric demand is known as potential evapotranspiration. However, as the soil dries, the available moisture decrease, hydraulic tension increase and transport of water to soil interface is insufficient to meet the demand and actual evapotranspiration is short of potential evapotranspiration.

The empirical methods normally relate Climatic parameter measurements to evapotranspiration. These relationships are usually affected by location, stage of crop development and season. Duru (1984) developed an empirical formula known as the Blaney-Morin-Nigerian evapotranspiration model which is expressed as in Equation 2 below:

$$E_{tp} = \frac{r_f(0.45T + 8)(520 - R_n^{1.31})}{100} \quad (2)$$

where,

$E_{tp} =$ Potential evapotranspiration, $mm\ day^{-1}$

$r_f =$ Ratio of maximum possible radiation to the annual maximum

T = Mean temperature in $^{o}C \left(\frac{T_{max} - T_{min}}{2}\right)$
R_h = Relative humidity in percent
T_{max} = Maximum daily temperature, ^{o}C
T_{min} = Minimum daily temperature, ^{o}C

The Blaney-Morin-Nigerian evapotranspiration formula was used to estimate daily potential evapotranspiration. The Climatological data considered in the above equation are the mean temperature, radiation and relative humidity. Daily values of this Climatic parameters beginning May to ending of October for each year were determined and used in a computer analysis to estimate daily value of potential evapotranspiration.

2.3. Actual Daily Actual Evapotranspiration

Crop Coefficients estimated by Adewumi (1980) for maize crop was used to adjust values of potential evapotranspiration. Actual Daily actual evapotranspiration is the product of daily potential evapotranspiration and crop coefficient as expressed by Gwarzo (1990).

$E_{ta} = K_c E_{tp}$ … (3)

Where,

E_{ta} = daily actual evapotranspiration mm day $^{-1}$
K_c = Crop coefficient
E_{tp} = daily potential evapotranspiration mm day $^{-1}$

2.4. Daily Change and Daily Storage of Soil Moisture

Daily change in soil moisture was determined using equation (4) below. On any day there is rain, the amount of actual evapotranspiration for the day with the amount of drainage and surface runoff as a result of the day's rainfall is subtracted from the actual amount of rainfall to give the daily change in soil moisture. On a non-rainy day the daily change in soil moisture is only the day's actual evapotranspiration, $E_{ta.}$ The daily change in soil moisture was determined by equation below; daily soil moisture storage for the period beginning May to ending October for each of the ten years wascomputed.

$$\sum_{i=9}^{n} DSM \quad \text{... (4)}$$

where

MS = daily soil moisture storage, mm

$\sum_{i=1}^{n}$ = daily summation carried out from day $i = 1$ to day $i = n$

DSM = daily soil moisture change, mm z

2.5. Tractability Conditions

A soil is considered tractable (or workable) if a machine can move on that soil to perform its function without damaging the soil, (Hassan and Broughton, 1975).Moisture content of the soil was selected as tractability criteria because field work when soil is too wet can result in serious soil damage and increased operating costs, while field work when soil is dry results in poor

operations.Therefore, tractability conditions for machine operations were established as a function of weather and soil moisture conditions. Amount of soil moisture within the top 30cm of the soil layer and the limits of daily rainfall were used as criteria.This criteria was used to differentiate between a "tractable" (workable) and a "non tractable" (non-workable) soil condition. For the farm soil condition or type (light), a workable day is that which has soil moisture content within the 30cm soil profile layer of between 95 percent of field capacity and lower plastic limit. Maximum rainfall for a workday should not exceed 7mm on that day while the previous day rainfall should not exceed 14mm (Gwarzo, 1990). A non-workable day is that which has a soil moisture content in the top 30cm of the soil profile layer exceeding 95 percent of field capacity or has a soil moisture content below the lower plastic limit value. Maximum rainfall for a non-workday is above 7mm on that day and above 14mm the previous day. Best conditions for tillage are also described in Table 1.

Using parameters defining field conditions for tractability as in Table 1, the amount of soil moisture in the top 30cm of the soil profile at field capacity, liquid and plastic limits was determined using equation (5)

$$A_w = \frac{B_d F_c D}{100} \quad \ldots (5)$$

where,

$A_w =$ Amount of soil water, mm

$B_d =$ Bulk density

$F_c =$ Moisture content at field capacity

$D =$ Soil depth, mm

This soil moisture values with rainfall values satisfying tractability was then applied to the soil moisture budget developed for the period to segregate between good and bad field workdays by a computer analysis as reported by Gwarzo, 1990.

Moisture content between lower plastic limit to upper plastic limit (liquid limit) to solid state of the soil were considered as best suited for tillage, Link (1968). As a function of soil moisture and rainfall, Table 1 gives the parameters defining field conditions for tractability.

2.6. The Computer Programme

A computer programme was written in Visual Basic 2008 language designed to compute daily soil moisture content for the period beginning May and to ending October for each year of the ten years and to further apply tractability conditions to the soil moisture balance to estimate good machinery field work days and days best suited for tillage at Badala farms. The computer programme used climate and soil information for the area to estimate suitable workdays for agricultural machinery.

3. RESULTS AND DISCUSSION

Table1 shows the total number of suitable fieldworkdays and best tillage workdays for each of the years assessed (1999-2009). Out of the 184 days working season duration for each of the years assessed for tractability conditions, the year (2001) had the lowest suitable days with 30.43 percent of the total time as suitable for fieldworkdays. This is close to the lowest value reported by Gwarzo (1990) reported (36.96 percent).The year 2000 had the highest estimated number of suitable work days with 54.35 percent of the total time as suitable for field work. A

corresponding value of 58.15% was obtained by Gwarzo (1990). The year (2001 and 2008) had the lowest number of best tillage workdays with (15.76 percent) of the total time as best suitable for tillage work and Gwarzo, 1990 obtained 17.39 percent. The year (1999) had the highest number of best tillage workdays with (36.96 percent) of the time as best suitable for tillage which is greater than the value obtained (35.14 percent) by Gwarzo, (1990) based on similar work conducted. The average number of good field workdays of the ten years working seasons was 40 days and the average number of best tillage workdays for the ten years was found to be 22 days and it is not in conformity with what Gwarzo 1990 obtained as 86 and 50 days as an average number of good field workdays and best tillage workdays respectively.

The number of suitable field workdays on a monthly basis for the period May through October for each of the years (1999) is presented in Figures 1. Likewise the tillage workdays on a monthly basis are presented in Figures 2. The months of June and August have the lowest number of average working days. This was largely attributed to low soil moisture in May, while the periods in August and September soil stays within field capacity range or mostly at saturation not allowing machine operations.

REFERENCES

Adewumi, J. K. (1980): Re- calibration of the Blaney and Criddle Evapotranspiration Equation for selected crops at Samaru, A project Report for B. Eng. (Agricultural Engineering) Ahmadu Bello University, Zaria pp78-101.

Babeir, A.S., Colvin T.S., and Movley, S.J. (1986): Predicting Field Tractability with a Simulation Model. Transaction of the ASAE 29 (6): 1520-1525.

Duru, O. J. (1984): Blarney- Morin-Nigerian Evapotranspiration Model, Journal of Hydrology, **70**, 71-83.

Gwarzo M.A.S. (1990): Capacitive Performance Study and Optimization of Power and Machinery on Large Scale Farm. Unpublished Ph D Thesis, Department of Agricultural Engineering Ahmadu Bello University Zaria, Nigeria, pp 18 - 26.

Gwarzo, M.A., Braide, F.G., Ramalan, A.A. and Mudiare, O.J. (1989): Computer Analysis for the Selection of Suitable Workdays for Agricultural Field Operations National Agricultural Extension and Research Liaison Services Ahmadu Bellow University, Zaria, pp 4-9.

Hassan, A.E. and Broughton R.S. (1975): "Soil Moisture Criteria for Tractability". Canadian Journal of Agricultural Engineering, **17**:124-129.

Link, D.A (1968) :Research Needs for Farm Machinery Scheduling Conference Proceedings of Computer and Farm Machinery Management, ASAE Publication Proceedings. p468.

Whitney, B. D. (1988): Choosing and Using Farm Machines. Land Technology, Edinburgh, Scotland, United Kingdom, p 412.

Table 1: Field Conditions for Tractability (light, medium and heavy textured soils)

PARAMETERS	CRITERIA
1. Tractable or Good Workday	Moisture content in the top 30cm of soil profile not to exceed 98% of field capacity (heavy textured soils) Moisture content in the top 30cm of soil profile not exceeds 95% of field capacity (light to medium textured soils). Moisture Content in the top 30cm of soil profile to be not less than lower plastic limit value of the soil (heavy, medium and light textured soils). Maximum rainfall yesterday (14mm) heavy, medium and light textured soils Maximum rainfall today (7mm heavy, medium and light textured soils
2. Non-Tractable or non-workday	Moisture content in the top 30cm of soil profile above 99% field capacity (heavy, textured soils) Moisture content in the top 30cm of soil profile above 95% of field capacity (light to medium textured soils). Maximum rainfall today above (7mm) (heavy, medium and light textured soils)
3. Best Condition for tillage	Moisture content in the top 30cm of soil profile between lower plastic limit to upper plastic limit (liquid limit) light, medium and heavy textured soils) Maximum rainfall yesterday (14mm). (heavy, medium and light textured soils) Maximum rainfall today (7mm). (heavy, medium and light textured soils)

Source: Gwarzo et al., (1989)

Table 1: Total Number of Suitable Field Work Days and Best Tillage Work Days and their Percentages in Total Time Assessed.

	No. of Days Assessed	No. of Good Field Workdays	Percent of Total Time	No. of. Tillage Workdays	Tillage Days as Percent of Total Time
1999	184	93	50.54	68	36.96
2000	184	100	54.35	55	29.89
2001	184	56	30.43	29	15.76
2002	184	89	48.37	61	33.15
2003	184	69	37.50	45	24.46
2004	184	62	33.70	34	18.48
2005	184	82	44.57	48	26.09
2006	184	82	44.57	44	23.91
2007	184	73	39.67	38	20.65
2008	184	67	36.41	29	15.76
2009	183	79	42.93	42	22.83

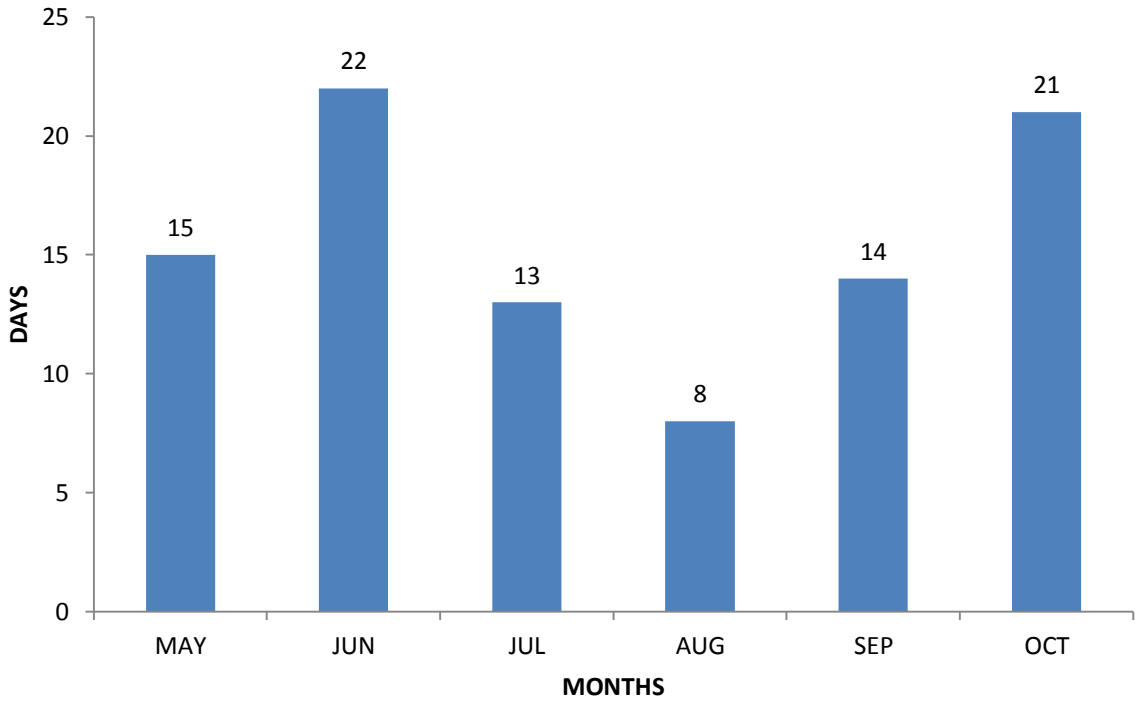


Fig 1: 1999 Estimated Number of Suitable Field Workdays for the Period Beginning May to Ending October

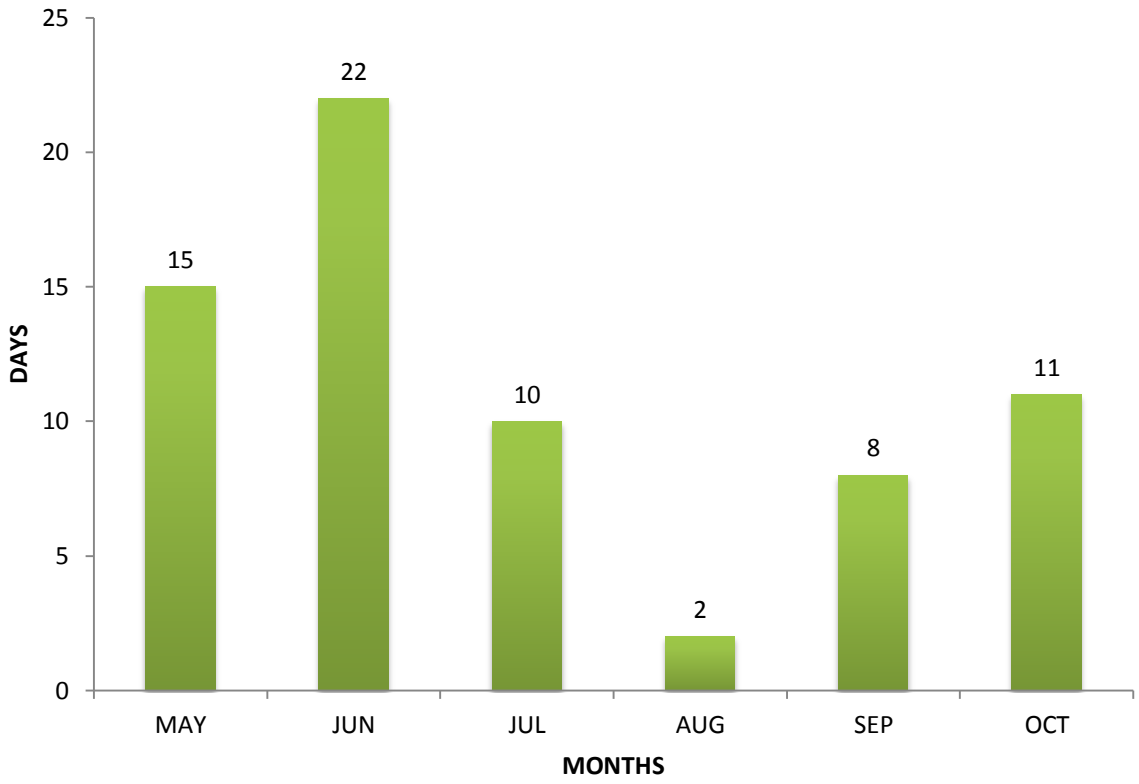


Fig 2: 1999 Estimated Number of Best Tillage Workdays for the Period Beginning May to Ending October

DETERMINATION OF PHYSICAL AND MECHANICAL PROPERTIES OF A SOIL RELATED TO THE DESIGN OF TILLAGE IMPLEMENTS

M.S. Abubakar and S.K. Shittu

Department of Agricultural Engineering, Bayero University, Kano-Nigeria.abubakarms@gmail.com; sarafadeenshittu@yahoo.com

ABSTRACT

This study represents the physical and mechanical properties of soil in respect to design of tillage implementat University Putra Malaysia (UPM) Research Park, Serdang Selangor, Malaysia. Soil samples were taken from the topsoil layer of 0-5cm and subsoil layers of 15-30 cm depths at six different locations on three different plots Blocks, A, B, and C having 675 m^2 sizes eachintriplet replications using 216 cm3 volume core samplers. Soil shearing characteristics, parameters thatinclude moisture content, bulk density, soil cohesion, angle of internal friction, shear deformationmodulus were determined in the laboratory using oven and direct shear box apparatus. Also an *in-situ*soil strength test was carried out. Soil texture was determined by standard analysis pipette method fromUSDA textural classification system.The mean values of soil moisture content and bulk densities obtained were 22.5 %, 28.5 %in Block A, 25.5 %, 23.2 % in Block B, 20.5%, 17.5 % in Block C, and 2.50 x 10^{-9} g/cm^3, 1.50 x 10^{-9} g/cm^3 in Block A, 1.20 x 10^{-9} g/cm^3, 1.40 x 10^{-9} g/cm^3 in Block B, 1.25 x 10^{-9} g/cm^3, 1.50 x 10^{-9} g/cm^3 in Block C, at the depths of 0-15 cm and 15-30 cmrespectively. Mean values of soil cohesion, angle of internal friction and shear deformation modulus were found to be 6.00kN/m^2, 1.85kN/m^2 in Block A, 5.60 kN/m^2, 1.65 kN/m^2 in Block B, 4.50 kN/m^2, 1.25 kN/m^2 in Block C, 30.2^o, 17.5^o, in Block A, 32.1^o, 17.8^o in Block B, 31.4^o, 18.2^o in Block C and 1.15 cm, 1.50 cm in Block A, 1.20 cm, 1.62 cm in Block B, 1.22 cm, 1.65 cm in Block C at the depths of 0-5 cm and 15-30 cm respectively. It was found that the *in-situ* shearing strength of the soil dropped from 3.30kN/$m^2$to 2.10kN/m^2in Block A, 3.12 kN/$m^2$to 2.36kN/m^2in Block B, and 3.18 kN/$m^2$to 2.48kN/m^2 as the depths increased from 0-15 cm and 15-30 cm respectively.

Keywords:Soil texture, moisture content, bulk density,cohesion, soil strength, tillage implement

1. Introduction

The purpose of a tillage tool is to manipulate (change, move, or form) a soil as required to achieve a desired soil condition. There are three important initial factors to be considered in tillage tool design. This includes; initial soil condition, tool shape, and manner of tool movement. As a result of these three initial independent input factors, another two output factors would be generated, namely; the forces required for manipulating the soil and the finally the obtained soil condition. All these five factors mentioned are directly connected to a tillage implement design. Among the initial three input factors, the designer has only complete control on the tool shape. The manner of the tool movement involves orientation of the tool, its path through the soil, and its speed along the path. For tools that travel in a straight line (i.e., not rotary or oscillating tools), the path is usually identified by merely specifying the depth and width of cut. Orientation of a tool with a particular shape may significantly affect both the soil manipulation and the forces. Most of the time, the linkage system used to position a tool affects both depth of cut and orientation of the tool. When sufficient power is available, speed is the easiest design factor to vary. Increasing the speed generally increases draft but also affects soil movement and breakup.

Agbede(2010) reported that the soil physical properties are affected by tillage and fertilizer types. The soil under conventional tillage had relatively lower bulk density, water content, higher total porosity and temperature compared with zero tillage treatment. According to his research, the treatment conventional tillage produced the lower values of mean bulk density and soil water content which were statistically significantly lower than zero tillage. He concluded that soil bulk density and water content were significantly higher in zero tilled plots than in conventionally tilled plots. Osman*et al.*,(2011) investigated the effect of tilt angle of disc plough on some soil physical properties at the Sudan university. They reported that in Sudan tractor drivers usually use an angle close to maximum for decreasing the tillage depth, consequently decreasing power requirement without regard to the tillage quality and the impact that occurs on the soil properties. Also they maintained that the factors of soil (soil moisture content, organic material, soil bulk density, and structure), plough (plough weight, radius of curvature, and disc diameter), and operation (forward speed, width and depth) are controlled the performance of disc plough. Martínez*et al.*,(2008) evaluated soil physical properties (bulk density, soil porosity and particle density; Mean weight diameter (MWD)) and wheat root growth as affected by no-tillage system and conventional tillage (mouldboard plough with two disc harrow) in a Chile sandy clay soil. Soil bulk density was determined in 7.2 cm diameter soil cores with a manual hammer operation at depths 0-2 and 2-15 cm. Conventional tillage disturbs soil structure and may increase the risk of runoff and soil erosion, effects soil temperature, soil mechanical properties, soil water availability, the depth and distribution of roots.Blevins *et al.*,(1983)studied the evaluation changes in soil physical condition after ten years of continuous production of corn by no-tillage and conventional tillage methods. A four-bottom 40 cm trailing mouldboard plough was used to plough at depth 15-18 cm. Secondary tillage included two trips over the plots with tandem disc harrow cutting to a soil depth at 10 cm. Abu-Hamdeh (2004) investigated the effect of mouldboard plough, chisel plough and disc plough on soil bulk density. He concluded that dry bulk density was increased with increasing the axle load in the depth of 0 to 20 and 20 to 40 cm. The ability of the soils to hold moisture decreased and the available water capacity was also decreased by tillage systems. At the same axle load, infiltration rate for chisel plough was higher than disc plough and mould board plough, respectively. Rajaram and Erbach(1999) investigated the effect of drying stress of a clay loam soil on physical properties (soil bulk density, cone penetration resistance, shear strength, adhesion, aggregate size and stability) in the laboratory by method of one cycle of wetting and drying. Three drying stress treatments were made by wetting, air-dried soil of initial moisture content of 12% (on dry weight basis) to three different higher moisture contents, namely 36, 33 and 40%, and then drying each of them back to their original moisture content of 12%. Thus, the soil was subjected to three different degrees of drying stress. The results showed that the soil strength, adhesion, and soil aggregate size, increased with the degree of drying stress. However, the soil bulk density did not change significantly with the drying stress.A comprehensive understanding of the physical characteristics (bulk density, moisture content, porosity, particle size, and aggregate size distribution) and mechanical soil properties (cohesiveness, internal friction angle, shear stress and penetration resistance) are important in the designing and fabricating of any tillage implement.Consequently, this paper reports the laboratory and field results for the determination of the some physical and mechanical propertiesatUPM farm soil in relation to tillage implement design.

2. MATERIALS AND METHODS

2.1. Experimental Site

The experiments were conducted at University Putra Malaysia Research Park, Serdang Selangor, Malaysia; on three different plots having 675 m^2 sizes each during the year2009/2010. The site was located at longitude 101˚, 42.916′E, latitude 2˚, 58.812′N and an altitude of 46 to 48 m above sea level (Figure 1) with an average annual rainfall of 2548.5 mm with maximum and minimum temperatures of 33.1˚C and 23˚C respectively(Bockari-Gevao *et al.*, 2005).

2.2. Data Collection and Analysis

The field test was performed based on experimental design in randomize complete block designed (RCBD) and twenty grams of each sample were classified by mechanical analysis using the pipette method.The analysis of variance (ANOVA) and Duncan's multiple range tests conducted to analyze the data using the statistical analysis systems (SAS) 1996 software.

2.2.1. Soil texture

Undisturbed soil samples were collected from the topsoil layer of 0-15 and 15-30 cm depths at six different locations in blocksnamed A, B and C eachbefore tillage operation in three replications. All the 36 samples were dried in air at engineering soil laboratory of UPM. Big clods were broken with a wooden mallet. Then the soil samples were passed through a 2mm sieve, after which 20 grams from all the 36 samples were collected and weighted by weighting balance with accuracy 0.001g.Furthermore the weighted soilsamples were numbered and put in 600 ml baker. Then 50 ml distilled water with few drops of ammonia and 20 ml hydrogen peroxide (H_2O_2) were added. All the 36samples were heated with stove and stirred at the same time for 10 minutes. A 50 ml Calgon was also added to the soil sample after cooling down. 400 ml distilled water was added and the contents of the baker were transferred to a mechanical stirrer for 10 minutes. After stirring, the contents transferred into1000 ml cylinder and put the cylinder in water bath (28°C).To measure the weight of clay and silt particles, after 3minutes and 58 seconds, a 20 ml of the content was taken by means of pipette. The content of the pipette was transferred into previously weighted aluminum dish and oven dry at 105°C for 24 hours. After oven drying, the aluminum dishes with contents were weighted again.The equations (1-3) from (Kettler *et al.*, 2001) and (Teh and Jamal 2010)were used to obtained the particle size.

$$sand\ \% = \frac{ovendrysandmass}{originalsamplemass} \times 100 \qquad (1)$$

$$silt\ \% = \frac{ovendrysiltmass}{originalsamplemass} \times 100 \qquad (2)$$

$$Clay\ \% = 100 - (sand\ \% + silt\ \%) \qquad (3)$$

2.2.2. Soil bulk density and moisture content

The soil moisture content test was carried out in the laboratory by oven drying method. Undisturbed soil samples were collected from the topsoil layer of 0-15 cm and subsoil layer 15-30 cm depth at six different locations before tillage operation in three replications making the total of 36 soil samples using 100 cm^3 volume core samples as shown in (Figure 3).

The soil samples were collected in the field by core ring. The dimensions of core ring were measured with calliper for the purpose of soil samples volume computations. All samples brought

to the laboratory were weighted for their wet masses before putting in the oven at 105°C temperature for 24 hours. After twenty four hours the samples were taken out from the oven and weighted again for their dry masses. Then the bulk density, moisture content and porosity of the soil were determined. Soil bulk density was computed as the ratio of the mass of the oven-dried sample to the volume of the wet sample taken from the field. The soil moisture content of the sample was computed as percentage ratio difference between the mass of the wet sample and that of the oven-dried sample divided by the mass of the wet sample. Porosity of the soil was determined from subtracting the ratio of bulk density by particle density from 1 (for most mineral soils, particle density is considered to be 2.65 g cm^{-3}). These methods were adopted from (Teh and Jamal 2010).

2.2.3. Soil cohesion, angle of internal friction and shear deformation modulus

A Wykeham Farrance International (WFI) SLI 4Hw soil shear box laboratory apparatus (Figure 4) was used to obtain soil cohesion, angle of internal friction and shear stress. The soil samples were collected from the topsoil layer of 0- 15 and 15-30 cm depths at six different locations in the experimental site before tillage operation in three replications. The method adopted in this test was similar to the one reported byAtaur *et al.*,(2004)andAbubakar *et al.*,(2010).Theshear box laboratory test apparatus can measure shear strength of cohesive soil of even less than 0.3 kg/cm^2which triaxial or unconfined tests cannot measure.

The soil samples were prepared in a rectangular box and subjected to a consolidation load of 1 kg, 2 kg and 3 kg for 24 hours before the shear test. Then the shear box apparatus was set up to rotate at a shear rate of 0.025 cm/s and a maximum shear displacement of 12 mm. Readings on the shear displacement in cm and shearing stress in kN/m^2 were taken until failure occurred on the sample. From the relationship between normal stress and shearing stress the cohesion and the angle of internal friction were calculated.

$$\frac{\sum\left(1-\frac{\tau_s}{\tau_{\max}}\right)^2 j^2}{\sum\left(1-\frac{\tau_s}{\tau_{\max}}\right)^2 j\left[\ln\left(1-\frac{\tau_s}{\tau_{\max}}\right)\right]} \qquad (4)$$

Where K_w is the shear deformation modulus in cm, τ_{max} is maximum shearing stress in kg/cm^2, τ_s is the shear stress in kg/cm^2 and j is the shear displacement in cm.

2.2.4. In-situ shearing strength

A RMU 1012 digital vane field test apparatus which comprises a set of hollow rods for holding the vaneblade, a twisting instrument on the upper end for twisting the rod set and a digital measuring gearbox poweredby 12 V DC battery for measuring the twisting torque was used tocompute the *in-situ* shearing stress of thesoil. The vane shear field apparatus was set up to rotate at a twisting torque ranging between 500-600 kg cm at an accuracy of 1 kg cm resolution. Three vane blades with diameters of 4.4 cm, 5.4 cmand 6.4 cm were used to determine the *in-situ* shear stress of the soil samples at different depths when thetwisting instrument on the upper end for twisting the rod set was rotated at a speed of 12 ^{o}/s. Reading on thetwisting torque was taken for every 8 s until its completes 360^o revolution, then the maximum twisting torqueto complete 360^o revolution was also recorded. The method adopted in the test study was similar to the onereported by Ataur *et al.,* (2004).Measured values were used to compute the *in-situ* shearing strength of the soil using the equation proposedby Wong *et al.,* (2004) below;

$$\tau_s = \frac{3T}{2\pi r^2 \left(2r + 3H\right)} \qquad (5)$$

Where τ_s is calculated shearing stress in kN/m^2, T is the torque in kg cm, r and H are the radius and the height of the shear vane in cm respectively.

3. RESULTS AND DISCUSSION

3.1. Soil Texture

The result showed that the mean values of soil particle size with different texture content from clay, sand and silt were 23.91%, 53.54% and 22.55%, respectively. The soil was found to be sandy clay loam under the standard classification of soil texture.

3.2. Soil Moisture Content and Bulk Density

Table 1 shows the values of moisture content in soil at the different depths of 0-15 and 15-30 cm. It was observed that an increase in depth caused increase in soil moisture content in Block A while in Blocks B and C increased in depth caused decreased in the mean values of moisture content.Soil bulk density was found to increase with increasing in depths at Blocks B and C whereas at Block A increase in depth caused decrease in bulk density. Mean values of soil moisture content and bulk densities obtained were 22.5 %, 28.5 %in Block A, 25.5 %, 23.2 % in Block B, 20.5 %, 18.5% in Block C and 2.50 x 10^{-9} g/cm^3, 1.50 x 10^{-9} g/cm^3 in Block A, 1.20 x 10^{-9} g/cm^3, 1.40 x 10^{-9} g/cm^3 in Block B, 1.25 x 10^{-9} g/cm^3, 1.50 x 10^{-9} g/cm^3 in Block C, at the depths of 0-15 cm and 15-30 cmrespectively. The soil moisture content and bulk density results obtained in study is similar to one reported by Chang and Baker,(1973).

3.3. Soil Cohesion, Angle of Internal Friction and Shear Deformation Modulus

Table 1 shows the mean values of soil cohesion, angle of internal friction and shear deformation modulus at different depths.Mean values of soil cohesion, angle of internal friction and shear deformation modulus were found to be 6.00 kN/m^2, 1.85 kN/m^2 in Block A, 5.60 kN/m^2, 1.65 kN/m^2 in Block B, 4.50 kN/m^2, 1.25 kN/m^2 in Block C, 30.2^o, 17.5^o, in Block A, 32.1^o, 17.8^o in Block B, 31.4^o, 18.2^o in Block C and 1.15 cm, 1.50 cm in Block A, 1.20 cm, 1.62 cm in Block B, 1.22 cm, 1.65 cm in Block C at the depths of 0-5 cm and 15-30 cm respectively. It was observed that the mean values of soil cohesion and the angle of internal frictiondecreased with an increased in depth for all the three Blocks. While mean values of shear deformation modulus increased from with increasing depths for all the Blocks. This result is in agreement with one reported by Martínez *et al.*,(2008) and Wong *et al.*,(1979).

3.4. In-situSoilShearing Strength

Table 2 represents the mean values of *in-situ* soil shearing strength of the soil at different depths. It was found that the *in-situ* shearing strength of the soil dropped from 3.30 kN/m^2 to 2.10 kN/m^{2}in Block A, 3.12 kN/m^{2}to 2.36 kN/m^{2}in Block B, and 3.18 kN/m^{2}to 2.48 kN/m^2 as the depths increased from 0-15 cm and 15-30 cm respectively.From the result of analysis of variance (ANOVA) between the mean effects of normal stress andshearing stress on depth, it was found that there was a highly significant relationship between the normal stressand shearing strength when interacted at different depths at 95% confidence level. This finding agrees withthat of Ataur *et al.*,(2004); Wong *et al.*,(1982); andMark *et al.*,(1993). However it was also observed that shearstrength of the soil decreases with increasing soil moisture content.

4. CONCLUSION

The experimental results of both laboratory and field tests show that the mean values of soil moisturecontent and bulk densities obtained were 22.5 %, 28.5 %in Block A,25.5 %, 23.2 % in Block B,20.5%, 17.5 % in Block C,and 2.50 x 10^{-9} g/cm^3, 1.50x 10^{-9} g/cm^{3}in Block A, 1.20 x 10^{-9} g/cm^3, 1.40 x 10^{-9} g/cm^{3}in Block B, 1.25 x 10^{-9} g/cm^3, 1.50 x 10^{-9} g/cm^{3}in Block C, at the depths of 0-15 cm and 15-30 cmrespectively. Mean values of soil cohesion, angle of internal friction and shear deformation modulus werefound to be 6.00 kN/m^2, 1.85 kN/m^2 in Block A, 5.60 kN/m^2, 1.65 kN/m^{2}in Block B, 4.50 kN/m^2, 1.25 kN/m^{2}in Block C, 30.2^o, 17.5^o, in Block A, 32.1^o, 17.8^o in Block B, 31.4^o, 18.2^{o}in Block C and 1.15 cm, 1.50 cm in Block A, 1.20 cm, 1.62 cm in Block B, 1.22 cm, 1.65 cm in Block C at the depthsof 0-5 cm and 15-30 cm respectively. It was found that the *in-situ* shearing strength ofthe soil dropped from 3.30 kN/m^2 to 2.10 kN/m^{2}in Block A, 3.12 kN/m^{2}to 2.36 kN/m^{2}in Block B, and 3.18 kN/m^{2}to 2.48 kN/m^2 as the depthsincreased from 0-15 cm and 15-30 cm respectively.

REFERENCES

Abu-Hamdeh, N. (2004). The effect of tillage treatments on soil water holding capacity and on soil physical properties (pp. 699): Iinternational Soil Conservation Organization conference(ISCO).

Abubakar, M. S., Ahmad, D., Othman, J. and Sulaiman, S. (2010). Mechanical properties of paddy soil in relation to high clearance vehicle mobility. *Australian Journal of Basic and Applied Sciences,* 4(5): 906-913.

Agbede, T. M. (2010). Tillage and fertilizer effects on some soil properties, leaf nutrient concentrations, growth and sweet potato yield on an Alfisol in southwestern Nigeria. *Soil and Tillage Research,* 110(1): 25-32.

Ataur, R., Azmi, Y., Zohadie, M., Ahmad, D. and Ishak, W. (2004). Mechanical properties in relation to vehicle mobility of Sepang peat terrain in Malaysia. *Journal of Terramechanics,* 41(1): 25-40.

Blevins, R., Thomas, G., Smith, M., Frye, W. and Cornelius, P. (1983). Changes in soil properties after 10 years continuous non-tilled and conventionally tilled corn. *Soil and Tillage Research,* 3(2): 135-146.

Bockari-Gevao, S. M., Ishak, W. I., Azimi, Y. and Teh, C. B. S. (2005). Soil tilth index for Malaysian paddy field. *Malaysian Journal of Soil Science,* 9: 53-63.

Chang, B. S. and Baker, W. J. (1973). Soil parameters to predict the performance of off- road vehicle. *Journal of Terramechanics,* 9(2): 13-31.

Kettler, T., Doran, J. W. and Gilbert, T. (2001). Simplified method for soil particle-size determination to accompany soil-quality analyses. *Soil Scine,* 65(NebrasKa): 849-852.

Mark, T. M., Robert, G. H. and Randall, K. W. (1993). A system for measuring soil physical properties in the field. *Soil and Tillage Research,* 26: 301-325.

Martínez, E., Fuentes, J.-P., Silva, P., Valle, S. and Acevedo, E. (2008). Soil physical properties and wheat root growth as affected by no-tillage and conventional tillage systems in a Mediterranean environment of Chile. *Soil and Tillage Research,* 99(2): 232-244.

Osman, A. N., Xia, L. and Dongxing, Z. (2011). Effect of tilt angle of disk plough on some soil physical properties, work rate and wheel slippage under light clay soil. *International Journal of Agricultural and Biological Engineering,* 4(2).

Rajaram, G. and Erbach, D. C. (1999). Effect of wetting and drying on soil physical properties. *Journal of Terramechanics,* 36(1): 39-49.

Teh, C. B. S. and Jamal , T. (Eds.). (2010). *Soil physics Analyses* (Vol. 1): University Putra Malaysia

Wong, J. Y., Garber, M., Radforth, J. R. and Dowell, J. T. (1979). Characterization of the mechanical properties of Muskeg with special reference to vehicle mobility. *Journal of Terramechanics,* 16(4): 163-180.

Wong, J. Y., Radforth, J. R. and Preston-Thomas, J. (1982). Some further studies on the mechanical properties of Muskeg in relation to vehicle mobility. *Journal of Terramachanics,* 19(2): 107-127.



Figure 1- Experimental site

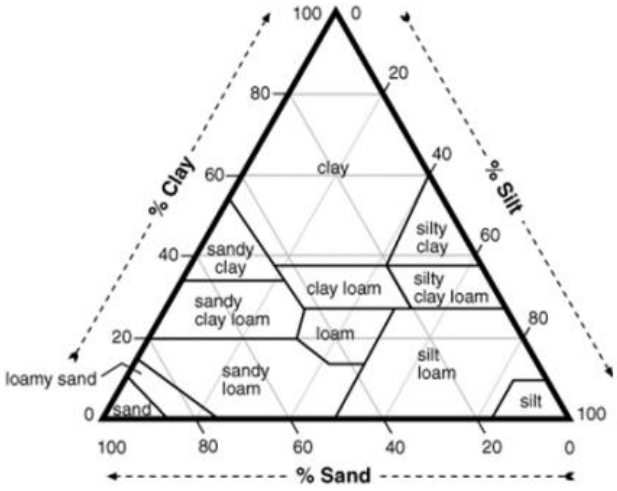


Figure0 - USDA Textural Classification System (Percent Sand ≥2mm to 0.050mm, Percent Silt = 0.050 mm to 0.002 mm, and Percent Clay is Finer Than 0.002mm)
Source : (Teh and Jamal 2010)



Figure 3- Set of equipment used for soil sampling



Figure 4 - Laboratory Soil Shear Strength Test Apparatus

Table 1 – Mean values of soil characteristicsat different depths

Soil Characteristic	**Block A**		**Block B**		**Block C**	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Soil moisture content (%)	22.5	28.5	25.5	23.2	20.5	17.5
Soil bulk density (g cm^{-3})	2.50	1.50	1.20	1.40	1.25	1.50
Soil cohesion, c (kNm^{-2})	6.00	1.85	5.60	1.65	4.50	1.25
Angle of internal friction, φ (^{o})	30.2	17.5	32.1	17.8	31.4	18.2
Shear modulus, K_w (cm)	1.15	1.50	1.20	1.62	1.22	1.65
Soil penetration resistance (N cm^{-2})	310		325		320	
Maximum shear stress (kN m^{-2})	42.20		40.15		38.12	

Table 2 – Mean values of *in-situ* shearing stress at different depths

	Mean shearing strength, τ_s (kN/m^2)					
	Block A		**Block B**		**Block C**	
Vane blade size, d (cm)	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
4.4	3.30	2.50	3.12	2.62	3.18	2.65
5.4	2.70	2.35	2.80	2.48	2.86	2.52
6.4	2.45	2.10	2.30	2.36	2.55	2.48

THE EFFECT OF SOIL MOISTURE CONTENT AND DEPTH OF PLOWING ON WHEEL SLIP ON A SANDY LOAM SOIL

Sule, S.,Ohanwe, C. N. and Atanu, S. O.

Agricultural and Bio-environmental Engineering Department Federal Polytechnic, Bauchi.
sulesamuel@yahoo.co.uk

ABSTRACT

This work is aimed at investigating the effect of soil moisture content and depth of work on tractor wheel slip on sandy loam soil of Bauchi, Bauchi State, Nigeria. The conventional method of wheel slip determination was used. The experiments were carried out on different days after rainfall to take care of the variabity in soil moisture content. The speed of operation was kept constant at 5.4km/hr. It was observed that the tractor wheel slip increased with increase in depth of plowing.

1. Introduction

Unless the engine power of a tractor is converted to traction power efficiently, either more energy is required to complete the operation or the work cannot be accomplished (Nice, 1997). Tractor working capacity is restricted by the losses along the power train. Approximately 12-18% of the engine power output is lost before it reaches the tractor's axle. One of the sources of power loss in the tractor is wheel slip (Nice, 1997).

Sule and Ezeaku (2005) stated that the basic condition for ensuring a correct working of tractor/machines aggregate is a right match of the tractor power to a given machine. Even with a good enough tractor power, the work of a tractor machines aggregates may be disturbed as a result of excessive wheel slip of the tractor drive wheel. This causes the deepening of the wheel into the ground and makes the motion of the tractor difficult eventually impossible. This in effect reduces the tractor speed and consequently the machine capacity leading to high fuel consumption.

If the soil has adequate moisture, tire tracks can be used to estimate wheel slip. This can simply be done by stopping the tractor and checking the tracks in front of the tillage tool. If slip is too high, the track will be broken up and if slip is too low, it will be much defined. Tracks should be slightly broken with the lug pattern still defined. Reducing wheel slip from 22 to 15 percent will save about one hour of operating time and expense in a 10-hour work day (Randy et al, 1991).

Tractive efficiency is the fraction of power available at the axle that is actually delivered to an implement through the drawbar. Power is transmitted most efficiently to surfaces that do not deform under pressure and where traction is great enough to prevent the wheels from slipping (Figure 1). Tractive efficiency on soils is limited both by rolling resistance and by wheel slip. Maximum power is available at the peak of each of the curves in Figure 1 where tractor parameters are commonly optimized to allow 8--15 percent slip. Power is limited by excessive rolling resistance on the left side of the curves and by excessive wheel slip on the right side of the curves. Maximum tractive efficiency results from a compromise between minimizing rolling resistance and minimizing wheel slip (Casady, 1997).

This work is therefore focused on examination of the effect of soil moisture content and depth of work on wheel slip on sandy loam soil of Bauchi. The knowledge of this will help farmers to properly and economically manage tillage operations.

2. MATERIALS AND METHODS

The experiment was carried out on a farm land close to the department of Agricultural Engineering Technology Federal Polytechnic Bauchi during the raining season. The soil is classified as sandy loam using the U.S Department of Agricultural Textural Classification chart after the sieve analysis was carried out. The area is flat. The experiment is to determine the optimum moisture content at which effective tractor operations are carried out on sandy loam soil. To vary the soil moisture content the experiments were carried out for five days. Each day of the experiment, the soil moisture content was determined using oven dry method. The distance of 100m of the field (sandy loam) was measured. At the beginning of the measured field, the rear tractor wheel was marked at the point of contact with the soil. The tractor was driven at a preset speed of 5.4km/hr. while the tyre revolutions were counted to the end of the marked field (for unloaded measurements). Next a plow was hitched and the tire revolutions to cover the same distance were counted (Loaded). The plowing depths were also adjusted to three pre-set depth 12.4, 16.2 and 18.8cm. The revolutions of the tyre were counted at the various depths of plowings. The tractor tyres were of bias ply type having a ply rating of 6-ply. The inflation pressure used was 20 psi, 1.37bar (137kpa). Tyre type is shown on plate 1.

The wheel slip was calculated using the equation:

$$\delta \text{ (Wheel Slip)} = \frac{N - N_0}{N} x100\,\%$$

Where N = number of wheel revolutions under load

N_o = number of wheel revolutions under no load

The use of tire tracks to estimate wheel slip is shown in Plates 2 and 3.

2.1. Precautions during the experiments

During the experiments, the following precautions were taken to minimize errors: The course was long enough to provide extra space at each end for starting and stopping. The tractor was operated far enough behind the mark that normal operating conditions are reached before the tractor passes the mark at the beginning of the course. The tractor was operated at the same speed. Good safety measures such as walking alongside the tractor at a safe distance from the tractor and implement was ensured and the use of oven dry method to calculate moisture content of the soil samples for accuracy was also ensured. Average values of ten readings are recorded.

3. RESULTS AND DISCUSSION

Results of the measurements are presented on Tables 1 to 3. Casady (1997) and Randy *et al* (1991) stated that the best tractive efficiency usually occurs when slippage is between 8% and 15%, depending on soil conditions. For sandy loam soil in this experiment, this corresponds to

between 5% and 13% soil moisture content wet basis. The relationship between soil moisture content and wheel slip on sandy loam soil is shown in Figure 2. In Figure 2, it can be seen that tractor wheel slip increases with depth of plowing and soil moisture content. The increase in wheel slip with increased depth could be due to higher moisture content of the soil beneath the soil surface. The logarithm equations show the relationship between soil moisture content and wheel slip for sandy loam soil. The correlation coefficients R show a very strong relationship between the soil moisture content and wheel slip.

4. CONCLUSION

Comparing the moisture content at which the best tractive efficiency usually occur when slippage is between 8% to 15%, it could be concluded that between5% to 13% moisture content of sandy loam soil, the cost of tractor operation will reduce and there will be increase in the timeliness of operation. It is hereby advised that farmers and tractor operators are patient at the onset of raining season for the soil to attain the optimum moisture content before moving in with their tillage operations.

REFERENCE

Karim Nice (1997) Howstuffworks "Torque, Traction and Wheel Slip" http://auto.howstuffworks.com/FourWheel-.htm. Page 1 - 4

Randy Taylor, Mark Schrock and Kelly Wertz (1991) Getting the Most from Your Tractor. Cooperative Extension Service, Kansas State University, Manhattan Issued in furtherance of Cooperative Extension Work, acts of May 8 and June 30, 1914,

Samuel Sule and C.A. Ezeaku (2005) Farm Machinery Management and Workshop Organization. PalmGate Printing and Publishing Company Bauchi Nigeria.

Schrock Mark, Taylor Randy and Kelly Wertz (1991) Farm machinery

And Equipment Getting the Most from Your Tractor. Department of Agricultural Engineering, published by Cooperative Extension Service Kansas State University Manhatan.

Steven, W. (1997) Measuring wheel – slip by Radar Gun, SAE Technical Paper series. SAE 1997 World Congress Detroit Michigan, March 4 – 7 1997.

William, W., Cassady (1997) tractor Tire and Ballast Management

Department of Agricultural Engineering, published by University Extension, University of Missouri-Columbia.

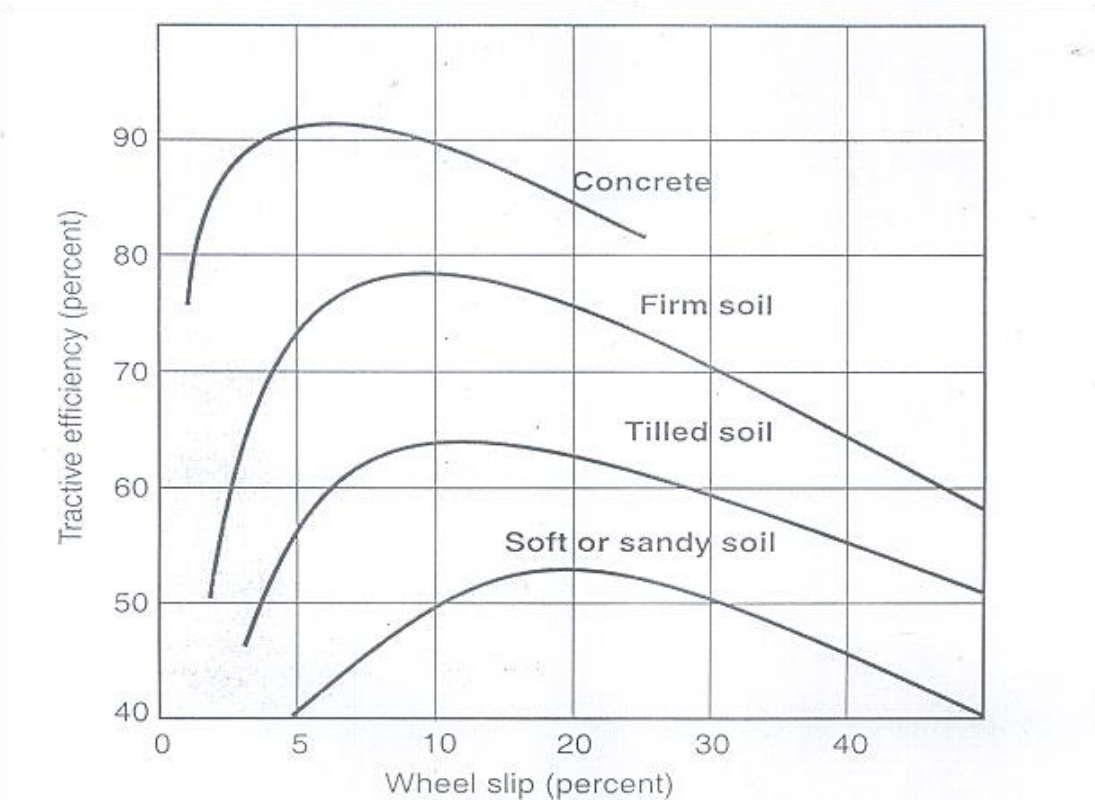


Figure 1 shows the relationship between tractor wheel slip and tractive efficiency (William, 1997).

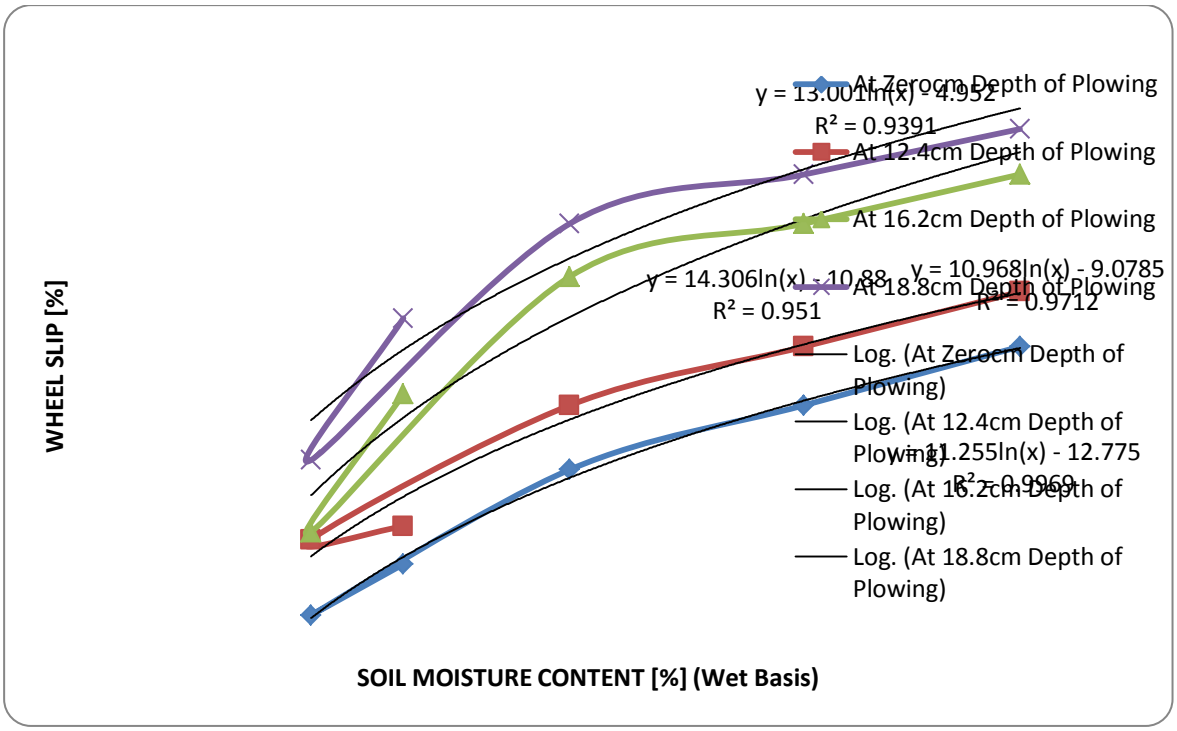


Fig.2:Effect of Soil Moisture Content on Wheel Slip on Sandy Loam Soil at Different Plowing Depths



Plate 1: A 2WD bias ply tractor tire



Plate 2: Tire tracks on loamy soils showing wheel slip at 12%



Plate 3: Tire tracks on Clay soils showing wheel slip at 12%

Table 1: Result of soil moisture and wheel slip determination

SOIL MOISTURE(%)	WORK DEPTH (cm)	WHEEL SLIP (%)
6	0	4.5
	12.4	8.7
	16.2	12.5
	18.8	16
7	0	4.3
	12.4	12
	16.2	15.4
	18.8	18.5
9	0	8.3
	12.4	15.4
	16.4	18.5
	18.8	21.4
16	0	8.7
	12.4	22.2
	16.2	25
	18.8	27.6
20	0	12.5
	12.4	25
	16.2	27.6
	18.8	30

Table 2: Result of soil moisture content determination

Weight of Soil sample before drying (g)	Weight of Soil sample after drying (g)	Moisture content wet basis (%)
245.4	231.3	6
225.8	209.8	7
246.8	225.4	9

251	210.9	16
221.1	177	20

Table 3: Result of sieve analysis for determination of soil type

Sieve sizes	Mass retained (g)	Percent retained (%)	Total passing
2mm	39.76	19.88	80.12
1.18mm	39.55	19.78	60.34
600micron	37.37	18.69	41.65
300micron	41.78	20.89	20.76
212micron	3.28	1.64	19.12
150micron	26.48	13.24	5.88
63micron	6.18	3.09	2.80
Passing 63micron	5.60	2.80	
Total	200	100	

TRANSPORTATION OF AGRICULTURAL PRODUCE AND CONSTRAINTS ON VALUE-ADDITION IN PARTS OF RURAL NIGERIA

Usman, D. D., Mohammed, B. and Haque, M. A.

Department of Agricultural and Environmental Resources Engineering, University of Maiduguri, P. M. B. 1069 Maiduguri, Nigeria. b1mohammed@yahoo.com

ABSTRACT

Transportation of agricultural produce from the farm to the house, processing centre, storage point and/or the market is a very important aspect in the overall foot chain, and it is a major thing that cannot be overlooked. A study was conducted to identify, among other things, the means of transportation, types of route used, cost of transportation, and losses during transportation of agricultural produce by farmers in 5 selected Local Government Areas of Adamawa State, Nigeria. A total of 100 households were considered in the study. Findings show that 47.21% of the households used four-wheel vehicles as the means of transportation, 17.98% used motor-cycles, 12.36% used bicycles, 10.11% used human porterage, 7.85% used ox-drawn cart and 4.49% used wheel barrow in the transportation of their agricultural produce. 51.68% of the households interviewed used untarred route while transporting their produce, 17.98% used tarred route while 30.34% used both. As regards transportation cost, 35.89% paid the highest amount of more than five hundred Naira, ₦500 (US$3.21) on transportation of their produce while 23.8% paid the least amount of ₦1 –₦100 (US$0.006 – US$0.64). Regarding losses during transportation, 32.86% lost more than 10kg, 30% lost 1-2 kg, and 20% lost 1-4 kg.It was concluded that the main problem of transportation of agricultural produce was untarred and poor road conditions and this had consequences, and majority of the farmers used four-wheel vehicles to transport their produce – the reason been the high-carrying capacity. The study recommends some ways of improving the transportation of produce more especially at the rural level so as to ensure that value-addition and economic well-being are achieved.

Keywords: Rural transportation, agricultural produce, Nigeria.

1. Introduction

Transportation of agricultural produce from one place to another is a very laborious but unavailable task, and it is a very important aspect (Adeoti and Kaul, 1988; Doran, 1994; Mijinyawa and Adetunji, 2005; Pretty et al, 2005; Higgins, 2006; Meisterling et al, 2009). The movement of goods is a major problem for rural households and it involves a significant proportion of farm labour, just as the transportation of agricultural and related goods has increased steadily in the recent decades (Gebresenbet and Ljungberg, 2001). Dannis and Anderson (1994) reported that up to 90% of travel in rural areas involves transportation of goods and a large portion of this is done by hand, back or shoulder carrying. Road network and vehicles are the two major components of transportation system. Mohammed et al. (1996) and Abbott and Makeham (1978) observed that lack of good network linking rural areas with the urban market remains one of the major causes of shortage of agricultural produce. This could have effect on the price of agricultural produce (Kilkenny, 1998). It was opined that agriculture by its nature must be or remain widely scattered over a large area, which implies the need for a good transport network (Upton, 1976). Omamo (1998) put it that improved rural road networks could help meet

food needs through domestic production and promote specialization that raises farm incomes. On the basis of a number of surveys in different countries it was observed that low-cost traditional methods of moving goods meet a much greater proportion of transport requirements than do conventional vehicles (Mohammed et al, 1996;Carruthers and Rodriguez, 1992). However low-cost vehicles have their own disadvantage in terms of load carrying capacity (tonne-km/hour). Typically, the load carrying capacity of a human being is 0.1, donkey (pack-load) - 0.25, bicycle – 0.8, motor cycle – 6, ox cart – 4 and single axle tractor – 10 tonne-km/hour. On the other hand, the load carrying capacity of a tractor/trailer is 60 and that of a truck is 500tonne-km/hour(Dennis and Underson, 1994). Clearly there is a very significant difference between these and the need to have good roads to transport agricultural produce efficiently is very important in the food chain. The objective of this study was to investigate the various means of transportation of agricultural produce, the types of routes used and the cost/losses incurred during transportation in some parts of Adamawa State, Nigeria. The study was necessary because very little information is available on the subject for this area and that farming is a major occupation in the area.

2. METHODOLOGY

1.2 The Study Area

Adamawa State is located in the north-eastern part of Nigeria and occupies about 36,917 km^2 of land with an estimated population of 3,168,101 according to the 2006 Nigeria national census. It is bordered by Borno, Gombe and Taraba States. Its eastern border forms the national border with Cameroon. Topographically, it is a mountainous land crossed by the large valleys of rivers Benue, Gongola and Yedsarem. The valleys of Cameroon, Mandara and Adamawa mountains form part of the vast landscape. The State has network of roads linking all parts of the country in addition to air and water routes which makes the State accessible in all seasons. The major occupation of the people is farming as reflected in their two notable vegetational zones, namely Sub-Sudan and Northern Guinea Savannah. The major cash crops grown are cotton, groundnuts, sugarcane and tea while food crops grown include maize, yam, cassava, guinea corn, millet and rice. Adamawa State is well known for cattle rearing and animal husbandry and possesses one of the largest population of livestock in the country. Additionally, fishing activities are carried out on the banks of the rivers by nearby communities.

The study was conducted in five selected Local Government Areas (LGAs) of Adamawa State, Nigeria (Fig. 1). These LGAs cover about one-third of the entire land area of the State. The LGAs were selected as being representatives of the region/State and they virtually practice similar agricultural activities having same soil type and climatic as well as topographic features. The major crops grown in these LGAs included maize, rice, sorghum, millet, cowpea and groundnut.

Two districts were chosen from each of the selected LGAs and tenrural households were considered randomly in each of the districts. Thus, a total of 100 households were surveyed during this study. The information was collected through personal contacts and direct interviews of farmers as well as administering of structured questionnaires. The information collected during the survey included means of transportation of agricultural produce, types of routes used, cost of transportation and losses occurring during transportation.

3. RESULTS AND DISCUSSIONS

Generally, it was found that agricultural produce are transported between farm, house, processing centre and markets. Oftentimes the transportation may not be systematic. Fig. 2 gives aschematic overview of the summary of the transportation of agricultural produce between various locations and the associated activities involved in the study area.

The different types of transportations used by the rural households in the study area are illustrated in Fig. 3. Majority of the farmers (47.21%) used four-wheel vehicles for transporting their agricultural produce probably due to the high-carrying capacity of these vehicles. The vehicles include pick-up vans, trucks, cars, Land-Rovers and tractors with trailers. Some of these vehicles were hired by the farmers while a reasonable number were owned by them. The additional considerations in the choice of this means of transportation were fastness, shorter time required for transportation and minimum loss/damage to the produce during transportation. It was observed that a considerable number of the vehicles were old, an indication that they have been used and maintained for a long time. However, if these vehicles are not in absolutely good conditions, there is the worry of supplementary greenhouse gase missions associated with agricultural produce transportation as shown in a recent study (Meisterling et al, 2009). Indeed, over a period of time, this cannot be overlooked because of increasing global concerns about climate change and its associated consequences.

Motor-cycle, bicycle, human porterage, ox-drawn cart and wheel barrow were used by 17.98, 12.36, 10.11, 7.85 and 4.49% of the farmers respectively. It was observed that these means of transportation were easier to own than the earlier category because they were cheaper to buy and often easier to maintain.

Fig. 4 shows that 51.68% of the farmers used untarred routes, 17.98% used tarred ones while 30.34% of the farmers transported their produce using both types of route. This was an indication of the limitation of tarred routes accessing the produce areas as at the time of the research. This situation had often led to delayed evacuation of produce from the farms and sometimes contributed to raising the price of produce at the market due to scarcity and also since farmers paid higher than expected to transport them there.

The high cost of transportation resulting from poor roads also increased the cost of production (as labour cost). Oftentimes farmers needed to hire extra labour to accomplish certain tasks, and poor road conditions meant increased transport cost to the hired-labours which were ultimately borne by the farmer. Table 1 shows the distribution of cost of transportation in the study area, with majority of the farmers (35.89%) paying high price. Again, this cannot be unconnected with the nature of the roads and difficulties associated with accessing the produce areas. It is easy to understand the correlation between produce loss and poor road condition. However, losses during transportation weregenerally less compared to losses occurring on the farm during storage often because of infestation and attack by rodents. Fig.5 shows the losses that occurred during transportation. Though losses occur as a result of poor roads, lack of good packaging or poor handling of produce were also identified as possible causes. However, a considerable number of farmers responded that they experienced minimal or no losses during transportation particularly when they used suitable packaging and good roads.

4. CONCLUSIONS

On the basis of the results from this study, it can be concluded that the main problem associated with the transportation of agricultural produce was poor road conditions and that most of the transportation occurred on the untarred roads. This situation had been identified as the primary cause of delay in produce evacuation. This often led to scarcity at markets and in this context the poor condition of roads was the main driver in raising the price of produce. It could also be said that the inability to evacuate the produce to the market could affect value-addition and it would be a major constraint to economic well-being to all concerned. Most of the farmers used four-wheel vehicles to convey their produce because of the high-carrying capacity although other means of transportation were more affordable in terms of purchase. Clearly, the main driver here was the carrying capacity. From the study, the following recommendations for the improvement of transportation of agricultural produce are made.

1. Rural and farming areas should be provided with good roads for easy access and timely evacuation of produce.
2. Government should put in a place a transportation mechanism that would assist farmers and ensure faster and safer flow of produce to intended destinations.
3. It is necessary to explore the potential role of small scale motorcycle-drawn carts with good carrying capacity over short distances in order to improve rural produce transportation. This would have the advantage of comparatively low purchasing price and good carrying capacity.

REFERENCES

Abbott, J.C. and Makehem, J.P. 1979.Agricultural Economies and Marketing in the Tropics. England: ELBS.

Adeoti, J. S. and Kaul, R. N. 1988. Assessment of Available Vehicles for Small farmers in Rural Areas of Nigeria. In*Proc. CIGR Inter-Sections Symposium,* ed.Oni, K. C. Nigerian Society of Agricultural Engineers. Ilorin, Nigeria,5 – 10September.

Carruthers, I. And Rodriguez, M. 1992.Tools for Agriculture: A Guide to appropriate Equipment for Small Holder Farmers. London: Intermediate Technology Publications Ltd.

Dennis, R. and Anderson, M. 1994. Improving animal based transport: technical aspects of Cart design. InImproving animal traction technology, eds. Sharkey, P., Mwenya, E. and Shares, J. Proc. First Workshop of Animal Traction New work for Eastern and Southern Africa (ATNESA) incollaboration with Technical center for Agriculture and Rural Cooperation (CTA, Wageningen, the Netherlands), 255-259. Lusaka, Zambia. 18-23 January, 1992.

Doran, J. 1994. Transportation by Women, and their Access to Animal-Carts in Zimbabwe. InImproving Animal Traction Technology, eds. Starkey, P., Mwenya, E. and Stares, J. Proc. First Workshop of Animal Traction New work for Eastern and Southern Africa (ATNESA) in collaboration with Technical center for Agriculture and Rural Cooperation (CTA, Wageningen, the Netherlands). Lusaka, Zambia. 18-23 January, 1992.

Gebresenbet, G. and Ljungberg, D. 2001. Coordination and Route Optimization of AgriculturalGoods Transport to attenuate Environmental Impact.J. agric. Engng Res., 80 (4): 329-342.

Higgins, A. 2006. Scheduling of road vehicles in sugarcane transport: A case study at an Australian sugar mill. European Journal of Operational Research, 170: 987–1000.

Kilkenny, M. 1998. Transportation cost and rural development. Journal of Regional Science, 38(2): 293–312.

Meisterling, K., Samaras, C. and Schweizer, V. 2009. Decisions to reduce greenhouse gases from agriculture and product transport: LCA case study of organic and conventional wheat. Journal of Cleaner Production, 17: 222–230.

Mijinyawa, Y. and Adetunji, J. A. 2005. Evaluation of Farm Transportation System in Osun and Oyo States of Nigeria. Agricultural Engineering International Ejournal,Vol. 7,Manuscript LW 05 004.

Mohammed, B., Haque, M. A. and Mustapha, A. 1996. Transportation of AgriculturalProduce by Farmers in North-East Nigeria. In Proc. Maiden National Engineering Conference, 22-28.Bauchi, Nigeria. 17-19April.

Omamo, S. W. 1998.**Transport Costs and Smallholder Cropping Choices: An Application to** Siaya **District, Kenya.** *American Journal of Agricultural Economics*, 80(1): 116-123**.**

Pretty, J. N., Ball, A. S., Lang, T. and Morison, J.I.L. 2005. Farm costs and food miles: An assessment of the full cost of the UK weekly food basket. Food Policy, 30: 1–19.

Upton, M. 1976. Agricultural production economics and resources use. London: Oxford UniversityPress.



Fig. 1: Map of Nigeria showing Adamawa State (inset as well) and the other 35 States and the Federal Capital Territory, Abuja.

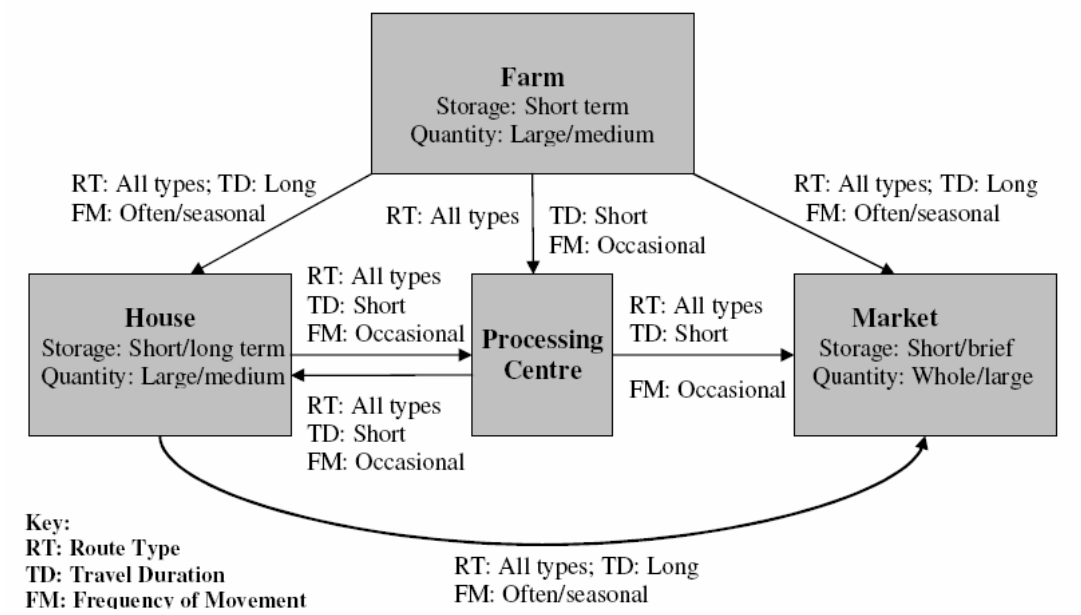


Fig. 2: Schematic of agricultural produce transportation between farm, house, processing centre and market with associated activitiesin the study area.

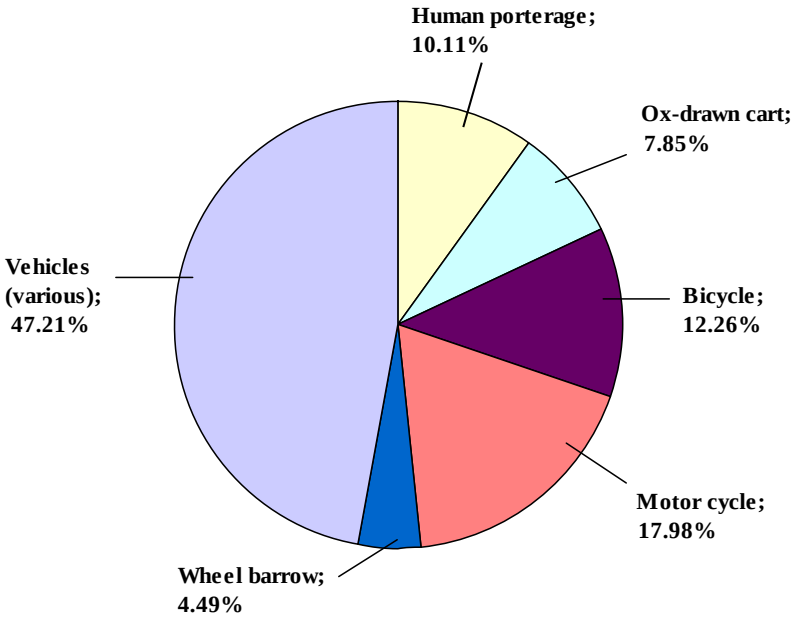


Fig. 3: The different means of transportation used for conveying agricultural produce.

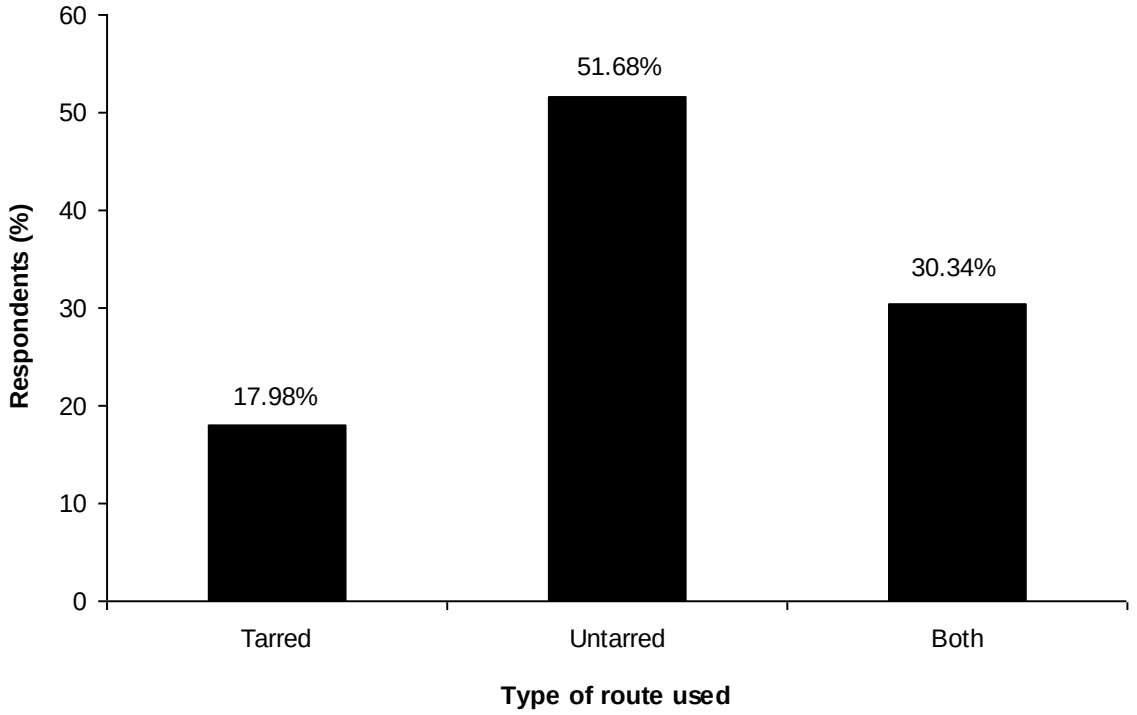


Fig. 4: Availability and use of tarred and untarred transportation routesby the respondents.

Table 1: Cost of transportation of agricultural produce in the study area

Cost of Transportation (₦)*	Respondents (%)
1 – 100	23.08
101 – 200	10.26
201 – 300	10.26
301 – 400	5.13
401 – 500	15.38
501 and above	35.89
Total	**100**

* - 1 US$ = ₦155.76 (Central Bank of Nigeria official rate as at 19-Oct-2012)

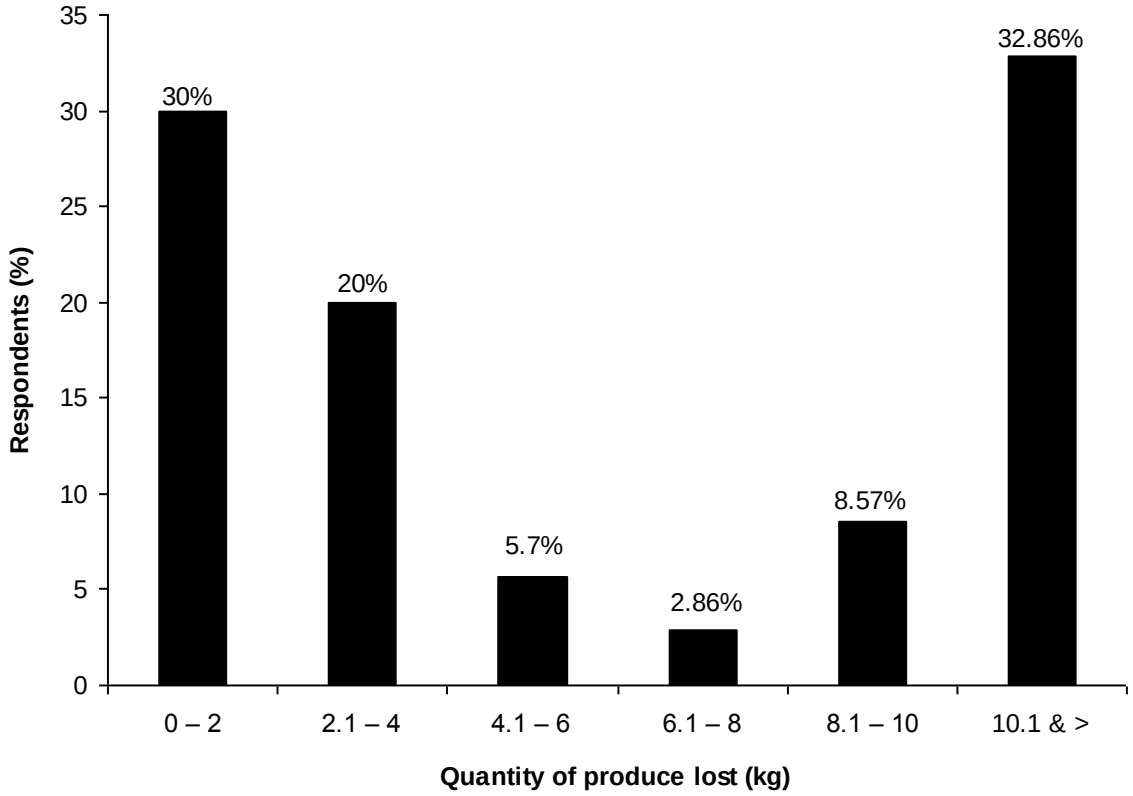


Fig. 5: The effect of type of route used on loss of agricultural produce during transportation.

ECONOMICS OF TRACTOR HIRING AND LABOUR COST IN LAND REPARATION INSOUTHWEST AGRO-ECOLOGICAL ZONE OF NIGERIA: ALTERNATIVE FOR AGRICULTURAL TRANSFORMATION AGENDA

***Wahab, A. A.,Issa, F. O., Arab, I. A. and Sale, N. A.**

National Agricultural Extension and Research Liaison Services,Ahmadu Bello University, Zaria
abdulhakeem.abdulwahab@yahoo.co.uk 08054788410

ABSTRACT

This study compares the costs of using hired labour with tractor hiring in land preparation (ploughing and ridging) in the South-west agro-ecological zone of Nigeria. It further focuses on the differences in the costs for 2008 and 2009. All the States within the zone were considered, using secondary data from 2009 annual agricultural performance survey report of NAERLS and NFRA. Data were analyzed using descriptive statistics. The results indicate that the cost of hiring labour is higher than tractor in most States. Results further indicate that the costs of tractor hiring as well as labour costs rose by 300% in some States between 2008 and 2009. Also, it was found that records of costs of land preparation were not kept by some States. Based on the findings, the study recommended that *land preparation*be fully mechanized so as to *reduce cost* of production and attain high crops yield programme of Agricultural Transformation Agenda (ATA). Also, tractor hiring units across the country should be well managed. The Government should subsidize the cost of tractor hiring to make it affordable by farmers. Finally, the new Federal Government Public-Private-Partnership (PPP) approach to tractorization should be given the desired dedication as a way of addressing the challenges facing the agricultural development in the country.

Key words: Economics, tractor-hiring cost, labour cost, land preparation, ATA

1. INTRODUCTION

The introduction of the nationwide universal primary education in the early 1970s and free education in the south western part of the country in 1979, reduced farm labour as many able bodied youths withdrew from the farms to go to school, and thereafter migrated to the urban areas in search of white collar jobs for which most of them were then adequately equipped (Anon, 1990).If the manual labour, which hitherto provided farm power, had dwindled at a time when the farmland had to be expanded, the only option was to increase the productivity of the reduced population on the farm. This required the introduction of methods with power output much more than could be provided manually. Animal traction was introduced to perform such tasks as ploughing and harvesting of crops especially groundnut. This was an improvement over the direct use of human labour but was restricted to environment that supported the survival of the draught animals (Minjinyawa and Kisaiku, 2006).

The Nigerian Government is confronted with a mission for self-sufficiency in food production for the over 120 million population; there are lots of pressures on the agricultural sector for food production as well as industrial raw materials. The country's food production has been growing at a rate of about 2.5 percent per annum while demand for food has been growing at about 3.5 –

4.0 percent.The high cost of ownership of farm tractors in Nigeria presently militates against the use of tractors by majority of the farmer (Ladeinde, 2010).Additionally, it is reported by Minjinyawa and Kisaiku (2006) that as a result of the high cost of tractors and implements, equipment ownership was mainly by government through the ministries of agriculture and lately by departments and parastatals whose mandate involved substantial land clearing and development. In order to make the services available to the farming populace who were not economically strong to acquire the equipment, special units were established and referred to as tractor hiring units. Hamidu and Simon (1999) maintainedthat even though the establishment of tractor hiring services was expected to make farmers have access to tractors and implements for various farm operations, this opportunity had not been fully exploited by farmers because of irregular and untimely availability of tractors due to frequent breakdown, lack of spare parts and bureaucratic bottlenecks. Thus farm operations, especially land preparation were still predominantly a manual activity.Ladeinde (2010)observed that for these and other agricultural development programmes to succeed, agricultural production, processing and utilization must necessarily move from its present subsistence level to a commercial level. This can only be accomplished through mechanization.

Economic considerations play an important role in land preparation activities, particularly in the selection of operational methods. The use of mechanized techniques is increasing rapidly along with a global trend towards more intensive forest-management and afforestation practices. In general, economic considerations come into the picture in situations where the simpler traditional techniques are being replaced by more complex mechanized operations for land clearing and soil ploughing. In land preparation operations, the initial cost of the treatment must be weighed against future returns in the form of material and functional benefits. A treatment which is too intensive may be uneconomical even though the result is an increase in volume (FAO,2006).
Jodinger (2010) maintained that it is of utmost important to examine whether the use of machines has been economical or not. Normally, there are good chances to reduce the cost of production if farm operations are mechanized as it saves labour, both human and bullock. In the absence of mechanization, the ever-increasing wage rate of human labour and cost of upkeep of draught animals could have increased the cost of production much higher. Furthermore, large scale production means less per unit cost on the farms. Moreover, it reduces the weather risk and risk of non-availability of labour and thus wastage is minimized.

The major problems associatedwith tractor use inNigeria include inadequatenumber of tractors, constant breakdown during operations and high cost of diesel or unavailability of spare parts especially at thepeak period of demand. All these factors contribute to cost incur in hiring the tractorsand may likely make the gap too wide when compare to labour cost. Also, the higher the cost of production the higher the price of farm produces and vice versa.Therefore, it is imperative to look at the economics aspect of the two so as to know which one to choose in a situation whereby the two are readily available. Manual methods in land preparation may be used in case wherelabour is cheap and easily available which will reduce the cost of production.
The objective of the paper is to compare the cost of hiring tractor to manual labour in land preparation and observethe one that is economically better and readily available.

2. MATERIALS AND METHODS

Data were obtained from the secondary source. The annual agricultural performance survey report of Nigeria jointly carried out by the National Agricultural Extension and Research Liaison

Services (NAERLS) and the National Food Reserve Agency (NFRA) was used. The South-west zone which comprises of eight States was considered. The States are: Delta, Edo, Ekiti, Lagos, Ogun, Ondo, Osun andOyoStates.All the States in the zone were considered for this study. The farm operations considered for the land preparation are ploughing and ridging for the year 2008 and 2009. It was analyzed using table, percentages and bar chart.

3. RESULTS AND DISCUSSION

Table 1 and figure 1 compare the cost of hiring tractors with the use of manual labour for land preparation in all the States in the south-west agroecological zones of Nigeria. It further compares the cost of land preparation for 2008 and 2009. The results indicate that the cost of labour is higher than tractor in most States. Furthermore, the results indicate that the cost of tractor hiring as well as labour costs rose by different percentages in most States between 2008 and 2009. Only five out of the eight States had complete record for both tractor and labour use. They include Ekiti, Lagos, Ogun, Osun and Oyo States. All the States recorded varying percentages of increase in the cost of land preparation from 2008 to 2009 using either labour or tractor. The use of labour costs almost thrice the amount incurred by farmers if tractor were used in Lagos, Oyo and Osun States(with Lagos being highest). This might not be unconnected with the metropolitan nature and the cost of living of these States.In Ekiti State, the cost of land preparation (using either tractor or labour) was the same in 2008 and 2009. Edo State recorded over 33% rise in the cost of tractor hiring between 2008 and 2009. The prices of foodstuffs in different markets throughout the zones could have increased due to these findings. This will consequently meet untold hardship on the rural and less previledged urban households who already finds it difficult to eat three square meals.

4. CONCLUSION

It is established that tractor hiring is more economical compare to labour cost in terms of land preparation for farming. Also, cost of land preparation increased in 2009 by at least 18.8%. Record of land preparation costs was not kept in some States. This situation is not healthy enough for any meaningful development in the agricultural mechanization sector of the country. The uneconomical nature of using labour for land preparation (and possibly other farm operations) underscores the dire need to properly address the tractor situation in the country.

It is recommended that right specification of tractor for different agro-ecological zones should be available and accessible by farmers at the right time and at the right price. This will help in achieving the Growth Enhancement Support (GES) of ATA programme designed to move subsistence farmers from their high poverty level into a commercialized system that would facilitate trade and competitiveness.

Moreover, *land preparation* should be fully mechanized in order to *reduce cost* of production and attain high crop production. Tractor hiring units across the country should be well managed. The Government should subsidize the cost of tractor hiring to make it affordable by farmers. Improper record keeping of tractor operations should be checked.

Lastly, all the stakeholders that are involved in federal government new approach to tractorization in the country's community cooperative tractor hiring service through Public Private Partnership (PPP), should be adequately sensitized so as to make it performs efficiently and effectively towards addressing the challenges facing the agricultural development in the country.

REFERENCES

Anon, (1990): Nigeria: A Country Study: U.S. Library of Congress http://countrystudies.us/nigeria/49.htm1 9/02/2006

FAO, (2010):Watershed management field manual Slope treatment measures and practices. www.fao.org/docrep/006/ad083e/AD083e02.htm

Hamidu, B.M and Simon, D.U. (1999): Comparative Analysis of Tractor and Non-Tractor Farm Operations Among Rice Farmers in Bauchi Local Government Area of Bauchi State. Proceedings of the Annual Conference of the Nigerian Institution of Agricultural Engineers, 21: 217 – 222.

Jodinger,S.(2010).Scope, Progress and Constraints of farm mechanization in India.India National Magazine, Volume 14, pp48-56.http://www.google.com/search?ie=UTF-8&oe=UTF-

Ladeinde, M.A. (2010).Tractor Operation Management for Sustainable Agricultural Production: Ammotrac Experience. Paper delivered at National Workshop on Tractor and Farm Machinery Management for Sustainable Agricultural Production organized by NAERLS/ABU 27th June – 3rd July, 2010 at NAERLS/ABU Conference Hall, Samaru – Zaria.

Minjinyawa,Y. and Kisaiku, O.O. (2006).Assessment of the Edo state of Nigeria Tractor Hiring Services. Agricultural Engineering International: the CIGREjournal. Invited Overview paper No. 10. Vol. VIII. March, 2006.

NAERLS and NFRA (2009). Annual Agricultural Performance Survey Report of Nigeria: 2009 Wet Season. NAERLS Press ISBN: 978-978-904-447-4.134p

Table 1: Comparing the cost of land preparation using tractor and manual labour in the South West

	Tractor hiring			Labour		
State	2008	2009	% Change	2008	2009	% Change
Delta	NA	9,000	-	NA	NA	-
Edo	8,000	12,000	33.3	NA	NA	-
Ekiti	6,500	6,500	0	8,000	8,000	0
Lagos	12,000	12,000	0	33,000	35,000	5.7
Ogun	4,500	6,200	27.4	4,500	6,000	25
Ondo	6,000	7,000	14.3	NA	NA	-
Osun	7,000	7,000	0	18,700	20,000	6.5
Oyo	7,500	8,500	11.8	20,500	27,000	24.1

Source: Adapted from Agricultural Performance Survey Report of 2009 Wet Season
NA: Not Available

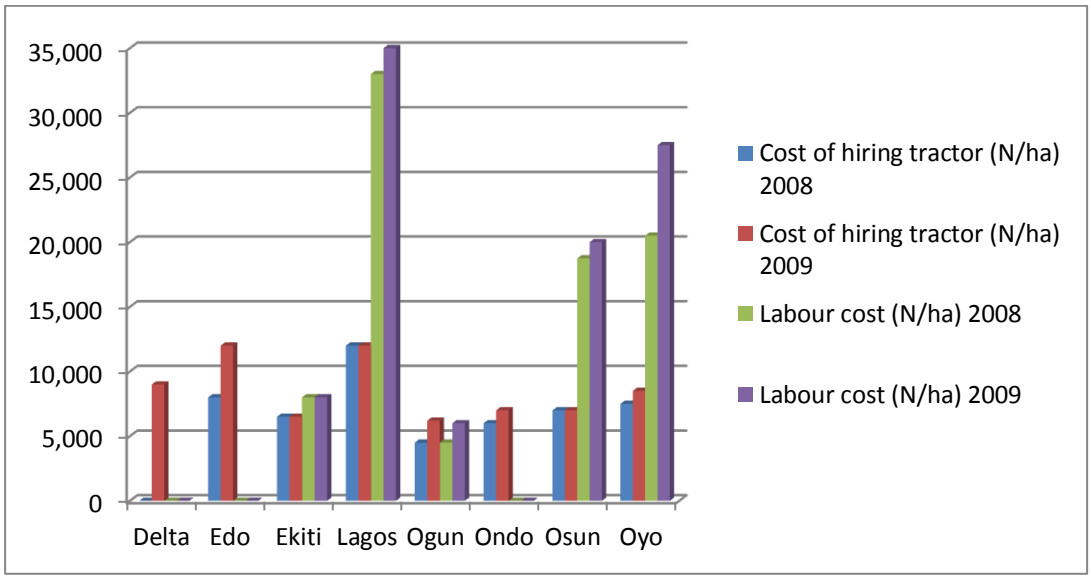


Figure 1: Cost of hiring tractor compare to labour cost for land preparation in 2008 and 2009 South West, Nig.

ADAPTATION OF A PAIR-LOADER HYDRAULIC RAM AS A DRAWBAR DYNAMOMETER

Ezema, A. O. and Obi, O. F.

Agricultural and Bioresources Engineering Department, University of Nigeria, Nsukka
francis.obi@unn.edu.ng

BSTRACT

In selecting tractors and implements, it is important that tractors must be large enough to meet the implement draft requirements. Thus, matching tractor power and implement size when it comes to tillage operation, the size of the tractor that can be used is often limited by the size of the available implement. The problems associated with matching of tractor power and implement size do result in too much power consumption/losses, and at times grounding the tractor. To measure these powers, various forms of force measuring transducers like the dynamometer are used. This study is focused on adapting a pair-loader hydraulic ram for use as a drawbar hydraulic dynamometer for field tests. It can be used to determine the drawbar pull and travel reduction (slip) of a tractor with implement in operation and when not in operation. A field test carried out showed with the instrument showed that at any given drawbar pull, the slippage increased with increase in draft (drawbar pull).

Keywords: Dynamometer, drawbar power, tillage operation

1.0 Introduction

There are many criteria that have been used to evaluate various tillage methods. The major areas include the effects of different tillage methods on physical and mechanical properties of the soil, crop emergence, growth and yield, relative costs and benefits (Anazodo et al., 1987). Tillage operation is one of the crop production operations requiring high energy input; a considerable amount of work and effort should be directed towards a practical evaluation of tillage operation with respect to its energy requirement. This is necessary in order to get the best fit between implements and power units in terms of energy efficiency. Output from power sources are measured using dynamometers. Dynamometer ranges from the hydraulic type, spring, strain gauge and absorption types to the transmission type. An attempt at constructing a hydraulic drawbar dynamometer was made by Onyezuligbo (1975) and was modified by Uke (1987). It is important to develop an instrument that will help in defining the tillage operations dimensions/data which are measurable, keeping to standards and reducing risks during field operation tests. Due to different ecological zones in Nigeria, the importance of the study will be better appreciated when looked at from the national point of view, because each zone has different soil characteristics. During field operation on these soils, field operating data for tillage machineries need to be compiled for under different soil types and conditions. This information can be used to determine the range of power requirement of such implements under the soil conditions. This makes it possible for proper matching of the implement to the appropriate power

unit. This implement-tractor matching is very important because it makes for appropriate work thereby, making the job economical by using the tractor of appropriate power.The matching of a power unit to an implement requires knowledge of the power requirement of the implement and depends not only on the engine power but on employing suitable tractive devices and ballasting to ensure that the power is available at the drawbar while a minimum is being wasted. However, proper matching of implements become difficult due to lack of information on the performance of tractor-implement combinations leading to consumption of excess energy and consequent high costs (Edathiparambil and Bhoop, 2002). The main objectives of this study are to adapt a pair-loader hydraulic ram for use as a hydraulic drawbar dynamometer and carry out a performance evaluation of the adapted pair-loader hydraulic ram.

2.0 Design Considerations

The adapted pair-loader hydraulic ram for use as a drawbar dynamometer consists of three main parts, namely: the hydraulic or pressure unit; the pressure measuring gauge orregistering device and the transmission line or connecting hose.The pressure unit consists of a cylinder, piston and push rod with the hydraulic cylinder having a capacity of 26.7kN draft was used. The maximum length of ram = 540mm, diameter of piston = 80mm, diameter of cylinder = 120mm. A hand held pressure gauge was used with maximum range capacity of 11N/mm^2. The transmission line was made of a high pressure oil rubber hose, 2.75m long, and hydraulic adaptors were used to connect the oil tube to the cylinder and the pressure measuring gauge. The assemble drawing of the fairly used Pair-Loader ram and the bracket are shown in Fig. 1 below.

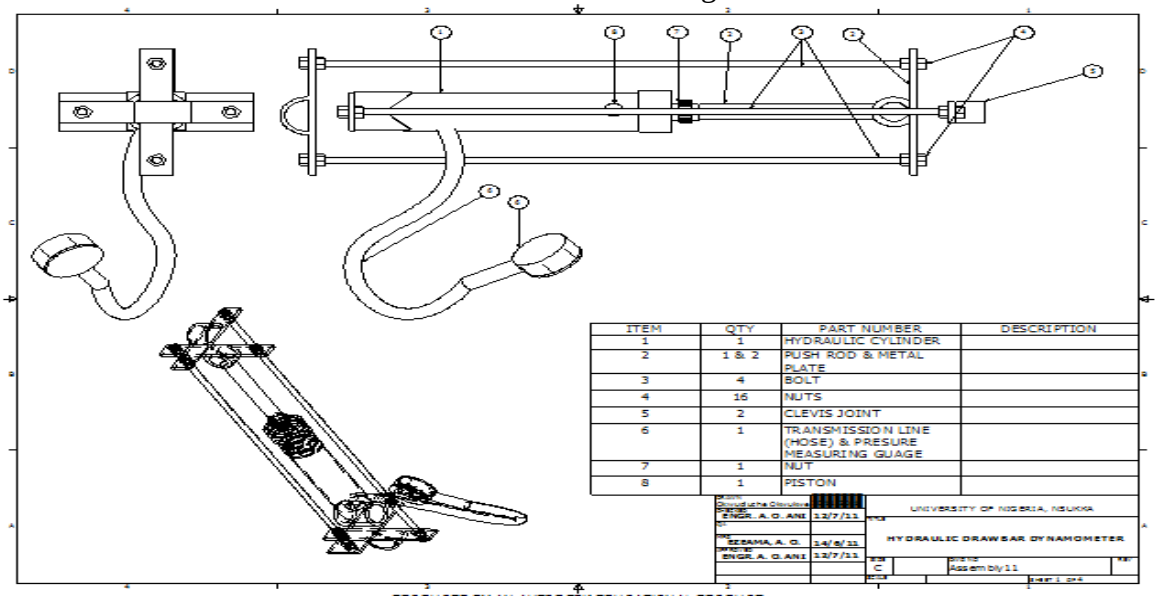


Figure 1: The assemble drawing of the pair-loader hydraulic ram for use as a drawbar hydraulic dynamometer.

3.0 Instrument Calibration

The selected pair-loader hydraulic ram was tested using a hydraulic crane of capacity 44.5kN at Science Equipment and Development Institute (SEDI), Akwuke, Enugu. The test was to check for leakages and to achieve a closed hydraulic system. The hydraulic ram was calibrated for accuracy with the use of a "universal testing machine" (UTM). Direct loading by use of known force at an incremental rate of 1000N per time was used in the calibration. The resulting gauge readings were noted. The unloading readings / using the same rate as for loading were also taken and corresponding pressure gauge reading and the length of the piston were also noted. The ratio of load to gauge reading was constant and the calibration curve is a straight line as in the calibration graph. The calibration test indicated a high factor of safety for the unit for it was designed to withstand 26,700N while the maximum applied load was 24,525N. The adopted pair loader hydraulic ram drawbar dynamometer calibration readings during loading and unloading are shown in Figures2 and 3 respectively.

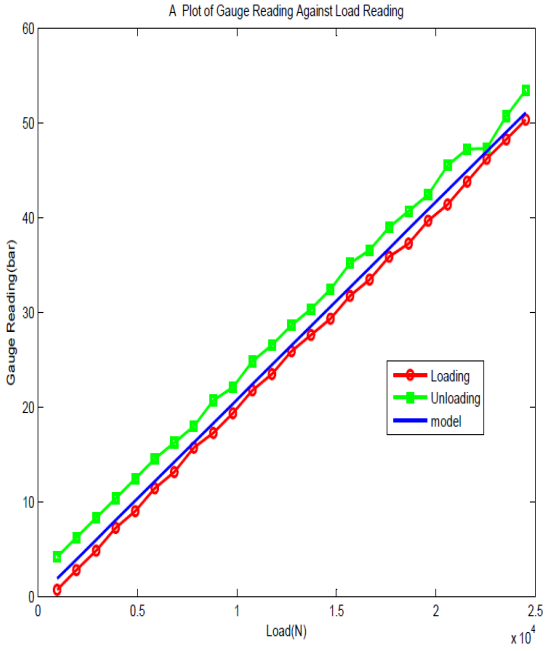


Figure 2: A plot of gauge reading against load reading

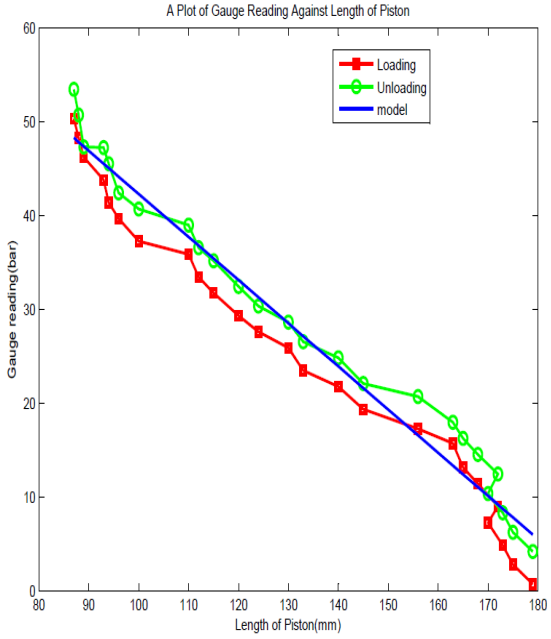


Figure 3: A plot of gauge reading against length of piston

The non-coincidence of the loading and unloading curves is due to: (a) the friction existing between the cylinder and piston (b) the internal friction or hysteretic damping of the stressed parts.

4.0 Test Procedure

The test was carried out in a grass covered land at the demonstration field of the department of Agriculture and Bioresources Engineering University of Nigeria, Nsukka. The tractor used to test the adopted pair loader ram used for hydraulic dynamometer drawbar was pulled by another

tractor that was connected to it by a chain and hydraulic drawbar dynamometer. The tractor used for the test was made to apply increasing drawbar loads by selection of the lowest gear of high speed (HI gear ratio). It was ran under constant engine speed of 1800r.p.m. Load changing for the gear selection was adopted to correspond with values of load from the calibrationreading during loading. In order to determine maximum possible draft, corresponding values of the dynamometer pressure gauge readings were recorded as the tractor hitched with the dynamometer was pulled.

4.1 Performance Test

A field test on the adapted pair-loader hydraulic ram was carried out to determine its suitability for use as a hydraulic dynamometer for field test. Table 1 and 2 present the results from the field test. In fig. 4, the graph of load and slip(travel reduction) show that slip increases with increase in draft when the implement is both in operation and out of operation. Also, fig. 5, the graph of gauge reading and slip show the same character as that of load and slip in the two conditions(implement in operation and out of operation). This goes to show that draft (drawbar pull) resulting to the dynamometer gauge reading are similar. Tire slip variability is dependent upon the load and other soil parameters. Thus increase in load shows an increase in slip but higher when implement is in operation as shown in graph of fig. 5. Figure 6 shows the dynamometer in field test.

Table 1: Performance test with tractor having implement not in operation

Runs	**Load N**	**Gauge reading**	**No of Rev.**	**Distance covered (m)**	**Distance per Rev.**	**% slip**	**Time taken (sec).**
		bar			**m/rev.**		
1	0	0	10	43.49	4.34	0	30
2	4000	8.618	10	41.61	4.16	4.15	31
3	4300	9.515	10	41.12	4.12	5.07	31
4	4900	9.791	10	40.80	4.08	5.99	32
5	5600	12.07	10	39.34	3.93	9.45	33
6	6400	13.79	10	37.73	3.77	13.13	33
7	7800	15.17	10	36.90	3.36	15.44	34
8	8100	17.24	10	35.90	3.60	17.05	36
9	9000	18.96	10	34.45	3.45	20.51	37
10	11000	23.58	4	16	1.6	63.13	12

Table 2: Performance test with tractor having implement in operation

Runs	**Load N**	**Gauge reading Bar**	**No of Rev.**	**Distance covered (m)**	**Distance per Rev.**	**% slip**	**Time taken (sec)**
1	0	0	10	42.51	4.25	0	31

2	2200	5.171	10	41.84	4.18	1.65	34
3	3100	6.895	10	41.52	4.15	2.35	36
4	3700	7.584	10	41.22	4.12	3.06	39
5	5600	12.07	10	40.14	4.01	5.65	43
6	8100	17.24	10	37.23	3.72	12.47	48
7	9500	18.62	10	36.25	3.62	14.59	49
8	11300	24.13	10	32.42	3.24	23.76	58
9	13000	27.58	10	26.14	2.61	38.59	64
10	14700	31.03	8	30.20	3.02	28.94	27

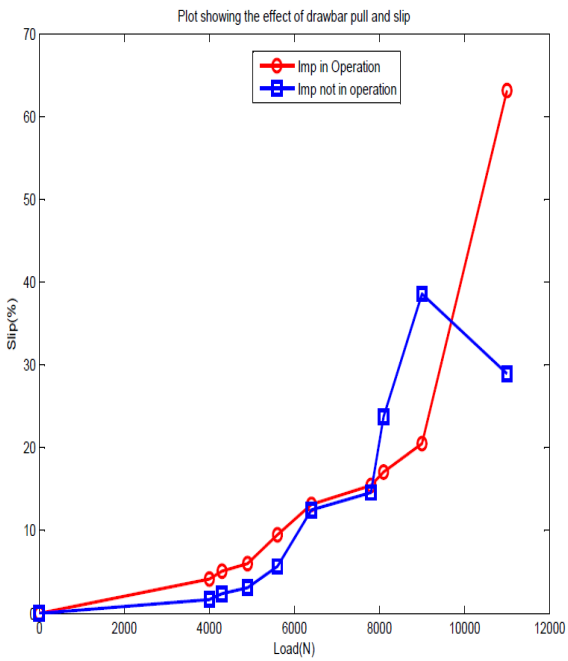


Figure 4: Plot showing the effect of drawbar pull and slip

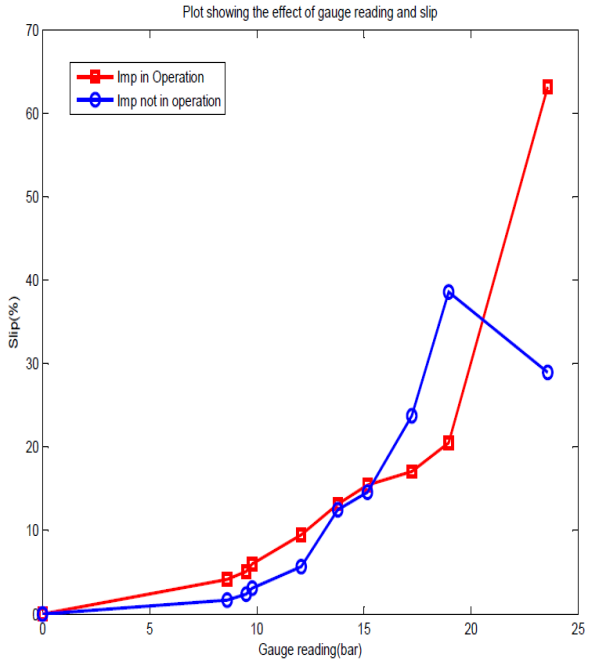


Figure 5: Plot showing the effect of gauge reading and slip



Figure 6: Dynamometer hitched at the drawbar

5.0 Conclusion

The adapted pair-loader hydraulic ram for use as a drawbar hydraulic dynamometer in the field tests was achieved. This was confirmed by the calibration and the field performance test data. The instrument will help in field test aimed at evaluation of some of the farm implements and machineries. In field test, it was observedthat increase in slippage obviously reduces the service life of the tires productivity.Thus, slip is the result of a correct drive wheel ballast since slip is controlled by adding or removing ballast from the tractor to obtain the desired slip.

6.0 References

Anazodo, U.G.N., A.P. Onwualu and M.N. Uke (1987). Draught and energy requirements in ploughing after five years of conventional and reduced tillage, proc. of the NSAE, Vol. 11, pp 108-120.

Edathiparambil V.T. and Bhoop Singh. Performance of Tractor Implement combination. Vol. 33 No 2 2002 Agricultural Mechanization in Asia, Africa and Latin America. Pg 25.

Onyezuligbo, C.O. (1975). Design, Construction and testing of a Hydraulic Drawbar Dynamometer. B. Eng. Thesis, Department of Agricultural Engineering, University of Nigeria, Nsukka.

Uke, M.N. (1987). Modification, calibration and use of the Hydraullic Drawbar Dynamometer. B. Eng. Thesis, Department of Agricultural Engineering, University of Nigeria, Nsukka.

AGRICULTURAL PRODUCTION IN TWO URBAN AREAS OF NIGERIA: A FIELD EVALUATION

Adama, J. C. and Onwualu, A.P.

Department of Agricultural Engineering, Michael Okpara University of Agriculture Umudike , P.M B. 7267, Umuahia Abia State. adamajoseph@yahoo.com 08039146246
Raw Materials Research and Development Council, 17, Aguiyi Ironsi Street, Maitama Abuja. ponwualu@yahoo.com 08037432497

ABSTRACT

The systems of agricultural production in two urban areas of Nigeria were evaluated on the basis of background of the farmers, type and location of enterprise, resources ownership, farming practices, constraints, etc. The two centres studied are Enugu and Nsukka in Enugu state. Methods of study were gradual urban approach and use of questionnaire. Results show that many residents of urban areas in Nigeria are engaged in one form of agricultural production or the other. This is caused by unemployment, poor, irregular, or denied salary,etc. Majority of the farmers fall within the ages of 41 – 60.The dominant enterprise is crop production (mainly vegetable) followed by livestock (mainly poultry).The major constraints to sustainable productivity are lack of basic resources, general urbanization and industrialization, pollution, lack of funds, etc. It is recommended that governments should formulate policies and programmes to assist the farmers in the sector for sustainable production.

1. INTRODUCTION

In the past, most of the significant agricultural productions in Nigeria are taken place in the rural areas wherever labour, water, land, etc were cheap and readily available, (Ijere,1991). The government was doing enough to support all farming activities then. During these periods, the country was experiencing urban to rural migration. People trooped to the rural areas to farm and only come to urban areas during festivals. Then, farmers were healthier, better dressed and recorded more achievements than the civil servants. The only agricultural activities taken place in the urban areas were practised by the colonial masters who kept animals as pets and small guards for production of ornamentals (Girberds and Girberds, 1977). But oil has since changed that picture (Ogunleye, 1992). Then, the agricultural share to GNDP was up to 80% (Odigboh and Onwualu, 1994). Not too long, the government abandoned these rewarding responsibilities in the sector by withdrawing its participation. This led to the collapse of the system. The major effect of this is that people especially the youths migrated to the urban cities in search of government job. In absence of the expected job in addition to harsh economic policies of the government the people have no option than to take to farming in the urban areas. Research shows that farming of different types and at various scales is taking place in many urban areas of Nigeria and extent of availability of the resources have been evaluated (Adama and Onuwalu, 2005).

Urban agriculture is defined as agricultural practices within and around cities which compete for resources such as land, water, energy, labour, etc. that could also serve other purposes to satisfy the requirements of the urban population. It could also be referred to small areas within the city for growing crops, and raising animals or milking cows and processing products for own consumption or sale to neighborhood markets (FAO, 2004). It also involves non wood forest products as well as ecological services provided by agriculture, fisheries and forestry (UNDP,

1977). The objective of this paper is to present a study undertaken to evaluate the systems of agricultural production in Nigeria. Two urban centres in Enugu state were used for the study.

2. METHODOLOGY

The methodology used in this research was the gradual urban appraisal approach. In this approach, nooks and crannies of the study area were visited on foot to identify the agricultural enterprises being practiced and their exact locations in the cities.

This exercise was undertaken by the author. The visit was first conducted in 2005 and validated between June 2007 and March 2012. Later, a questionnaire was developed and used to obtain other information and data from farmers. The information obtained include, the background of the farmers (sex, marital status, main occupation, education level and age). Other parameters obtained from the farmers are farming system/practice, resource ownership system, awareness index of the residents on the existence of farming practice in the area, constraints to urban farming, etc. Data obtained were analysed using percentages. The enumerators in this aspect of the research were one staff each drawn from Enugu state Ministry of Agriculture, Enugu State Agricultural Development Programme and Federal Department of Rural Development Enugu Field Office.

Ten samples of the questionnaire were given out to the enumerators to fill for validity. Questions that were ambiguous were restructured and they become clearer before they moved to the field. The interview phase of this research was first conducted between December 2008 and April 2009 and then validated in March, 2012. The results of the 2012 visits by the author and the interview by the enumerator were presented.

2.1. The Project Area

Enugu urban is the capital of Enugu state. It is a scap footed town lying on the plains close to the East facing Enugu- Awgu crest with rich formation known as the lower coal measures with crops at the foot of the escarpment (Oformata, 1978). The dominant vegetation is the tropical rainforest and the soils of the area range from low to medium productivity potentials. The mean annual temperature is 21^0C while the rainfall ranges between 1520mm and 2030mm (Aneke, 1991). It consists of three local government areas namely; Enugu East, Enugu North, and Enugu South all have a population of 722.664 (Census, 20006). On the other hand, Nsukka urban area is the second most important town in EnuguState. It possess a distinctive physique dominated by a cuesta land scape with a long rain season (April to October) and four land form divisions (Oformata, 1975).The dominant vegetation is the derived savannah (Onwualu and Anazodo,1988). The mean daily minimum and maximum temperatures are 21^0C.and 27^0C.respectively. From October to February, the relative humidity is between 35 to 65% and 60 to 85% during the rest of the year. Annual rainfall ranges from 980 mm to 2,088mm.The city can grow crops all year round where there is corresponding supply of water (Inyang, 1978).

3. Results and Discussion

3.1. Background of the Respondents

Table 1 gives the sex, marital status, occupation, educational attainment and age of the respondents. From the table, 51% of the respondents in Enugu urban are males while in Nsukka, 48% are males. That is, there are more male farmers in Enugu urban while in Nsukka urban, there are more female farmers. Also, more respondents in the two centers are married. For instance, in

Enugu urban, 65% of the respondents are married, 34% are single and 1% are divorced while in Nsukka, scores are 69% married, 31% single and 0% divorced. On occupation, majority of the respondents are disengaged, retrenched or retired. In Enugu urban, the score is 64% and for Nsukka, it is 56%. Active civil servants constitute 30% of the respondents for Enugu urban and 34% for Nsukka urban. Traders have the lowest record of 6% for Enugu and 10% for Nsukka. On educational level, most of the farmers in the two centres are literate. 98% of the respondents in Enugu have at least First School Leaving Certificate while in Nsukka, the score is 79%.
In the two centres, majority of the farmers are between the ages of 41 and 60 years as the score is 55% for Enugu and 58% for Nsukka. This group constitutes disengaged or retrenched civil servants together with low income workers.

3.2. Evidence of Urban Agriculture, Location and Types of Enterprise

In Table 2, some areas where agricultural activities are taking place in the two urban centres are presented. Also in the table are the types of enterprise. From the survey, 21 areas were identified in Enugu urban while in Nsukka 6 areas were identified. Enterprises include crop production livestock production, waste recycling/management, crop processing, storage, etc. Some of the areas as indicated in the table which existed during the previous studies have given to urbanization and general infrastructural development. There are one of such cases in Nsukka and four in Enugu.

Table 3 gives empirical evidence of farming in the study areas (specific enterprise). From the table, majority of the farmers are engaged in crop production (35% in Enugu urban and 39% in Nsukka urban). This is followed by livestock production with a score of 23% for Enugu urban and 26% for Nsukka urban. Scores of other enterprises are waste management 5% for Enugu urban and 0% for Nsukka; meat/crop processing, 17% for Enugu and 20% for Nsukka; horticulture 8% for Enugu and 5% for Nsukka; storage 11% for Enugu and 10% for Nsukka. Other enterprises not listed in the questionnaire scored 1% for Enugu and 0% for Nsukka. The scores for specific crops cultivated, products processed and/stored and livestock raised are also presented on the table. For crop being cultivated, vegetable has the highest score in the two centers (48% for Enugu and 55% for Nsukka). Poultry ranked highest for livestock (70.1% for Enugu and 69.8% for Nsukka). For products processing, grain has the highest score in the two centres. More farmers (60%) store grains in Enugu urban while in Nsukka urban majority of the farmers (39%) store palm oil.

3.3. Type of Farm Practice

The farm practice adopted by the farmers in the study area is presented on Table 4. From the table, only 3% of the farmers adopt mechanized ploughing in Enugu urban while in Nsukka urban nofarmerpractices any form of mechanized tillage Majority of the farmers in the two centres (62% in Enugu and 53% in Nsukka) use poultry droppings as manure. This is followed by the use of human faeces at Nsukka (22%) and inorganic fertilizer at Enugu (20%). The least score are for farmers using plant residue for management, the score is 03% for Enugu urban and 07% for Nsukka urban.

3.4. Ownership of Resources

The system of ownership for the resources studied is presented on Table 5. From the table, most of the farmers do not own the resources they are using. The resources are classified as follows; land, power (not including manual) and water (not including rain). Most of the resources belong

to either the government or private individuals but used by farmers either on hiring or lease at a determined rate. For land, 05% in Nsukka and 10% in Enugu cultivate on their lands, and 80% in Enugu and 82% in Nsukka cultivate on lands belonging to private individuals which were given out on lease Others farm on government lands.. 10% percent of the farmers in Enugu urban and 05% of them in Nsukka use water provided by the government for their agricultural production. This revelation points to the fact that the farmers in the two urban areas depend on flowing streams and rainfall for agricultural production especially for field crop production. On power resource, 22% of the farmers who have access to mechanical source of power in the two urban areas own the resource. 55% and 78% of the power sources utilized in Enugu and Nsukka respectively are owned by private individuals. Farmers in Nsukka urban areas have no access to government or company owned mechanized power source. The types of power systems studied are stationary (processing machines) and mobile (field machinery). The extent of availability of the power system for field operations, the size of land cultivated by the farmers and the extent of their dependent on the identified sources of water for farming operations were further analised and presented in another report (Adama, and Onwualu, 2012b).

3.5. Awareness Index

Result of the field evaluation on the awareness index of the residents on urban agriculture (Table 6) gave a very high awareness index (100%) for the farmers in the two urban areas. That is, all the residents of two urban areas interviewed are aware of existence of agricultural activities in the areas.

3.6. Charging Rates

For land, the rate is as high as ₦3000/ha/season in Enugu and ₦1000/ha/ season in Nsukka. For water, there are no charges for rain fall, streams and water from burst pipes in the areas. For direct water from pipes, users pay to Water Corporation. For tractor service, the charge is ₦15, 000 per day charged by private and ₦ 8000 per is charged by Enugu State Ministry of Agriculture. This charge excludes oil, diesel and feeding of the operator which is about ₦ 10,000 per day.

Most of the farmers who used mechanical input obtained service from Enugu State Tractor Hiring Service, Federal Department of Rural Development, Ozonwani Farms Ngwo, and Enugu State Agricultural Development Project. This was the case in the previous studies. The 2012 study revealed that only the private hire and the ministry have tractors to hire out this season. Tractors available in other agencies have broken down. Functional ones are held by policy maters. However, tractorized services are limited to only 18% of the farmers in Enugu urban and no farmer in the Nsukka has access to tractor services.

3.7. Constraints to Urban Agriculture in Enugu and Nsukka Urban Areas

Analyses of the information from the questionnaire show that the farmers' willingness to increase their farm enterprises in the urban areas of Nigeria is limited by the following factors:

I. Inadequate basic resources

The basic resources such as land, water, mechanical power, etc needed for mechanized agricultural production are lacking in the area of study. This has affected negatively the farmers' output as his production capacity has remained low. A study to quantify the extent of availability of these resources has been done..

II. Environmental pollution:

Some non biodegradable industrial wastes, smoke and noise from automobiles pollute soil and air and so reduce the fertility of the soil for crop production. Noise affects livestock.

III. Lack of time

Some of the farmers are civil servants, traders and craft men who farm on part-time basis. This takes away the time that is supposed to be used to take care of the enterprise especially crops and livestock.

IV. Urbanization and Industrial Development

Urbanization and industrial development lead to top soil and forestry removal, the consequences of which includes flooding, erosion, depletion of soil nutrients which will in turn affect crop performance. In most cases, cropped lands, livestock houses, processing houses, etc are destroyed or pulled down to give way to roads, industries, buildings, water pipelines, utility cables, etc.

3.8. Prospects for Urban Agriculture in Nigeria

Lack of employment opportunity for many youths who migrated from the rural to urban area, disengagement and reform policies of the government, low level and irregular payment of salary, increase in house holds, availability of wastes, availability of open spaces and water, bad market manufactured goods, taste for fresh foods stuff such as vegetables and fruits and very high awareness index of the farmers on the existence of farming activities in urban areas, etc are the factors that encourage agricultural production in urban areas of Nigeria.

4. CONCLUSION

The Following conclusions are drawn from the research:

(1) Agricultural production is practised in Enugu and Nsukka urban areas of Nigeria.
(2) Crop (mainly vegetable) and livestock (mainly poultry) production top the list of
(3) agricultural enterprises in the study area.
(4) Majority of the farmers are either active, disengaged or unemployed residents of the cities and are aged between 41 to 60 years.
(5) Availability of open spaces, agricultural wastes, livestock droppings, low salary, lack of job opportunity, etc are some of the factors that encourage agricultural practice in the study area.
Lack of basic inputs, urbanization, industrialization, pollution, etc are some of the constraints that affect increased agricultural production in urban areas of Nigeria.
(6) There is no programme of the government to aid agricultural production in Enugu and Nsukka urban areas of Nigeria.

Agricultural production in urban areas is a known practice no only in Nigeria but world over. Governments should formulate policies and programmes that will assist the farmers mechanize the production systems and thus increase production. Also research institutes should sponsor research in that sector.

REFERENCES

Adama J.C. and Onwualu. A.P. 2005. Assessment of Engineering Resources for Mechanized Agricultural Production in Two Urban Areas of Nigeria. Unpublished Research Report. Department of Agricultural Engineering, Faculty of Engineering University of Nigeria Nsukka

Nigeria. pp 31

Adama J.C. and Onwualu. A.P. 2005 Assessment of Engineering Resources for Mechanized Agricultural Production in Two Urban Areas of Nigeria.Unpublished Research Report. Department of Agricultural and BioresourcesEngineering, Faculty of Engineering University of Nigeria Nsukka Nigeria. pp 31

Aneke, D. O. 1991. Design and Formulation Studies on Agu Ukehe NALDA Farm in Enugu State.

FAO 2004. Food and Agriculture Organization. Report on Urban and Peri-urban Agriculture. FAO x 00 76, Rome Italy.

Gibberd, A.V and Gibberd, V.L 1977. A Gardening Note Book for the Tropics. Longman Group Ltd London. ISBN 58260828 7.

Ijere, M. O. 1991.The Challenges of Rural Development in Nigeria. Unpublished Research Report. CRDC. Faculty of Agriculture, University of Nigeria Nsukka Nigeria

Inyang, P. E. B. 1978. The Climate of Nsukka and Environs. In Nsukka Environment,Forth Dimension Publishers, Enugu.

Odigboh, E. U. and Onwualu A. P 1994. Mechanization of Agriculture in Nigeria: A Critical Appraisal. Journal of Agricultural Technology (2). 1-58.

Ofomata, G.E.K 1975. Nigeria in Maps. Ethiope Publisher. Benin City Nigeria.

Ogunleye, G. 1992. The Rejected Stone now the Reference Point. Budget Review (7) Agriculture. The Guardian Publication. January 13, pg 8.

Onwualu, A. P. and Anazodo U. G. N.1988. Field Evaluation and Cost Benefit Analysis of Alternative Tillage System for Maize Production in the Derived Savannah Zone of Nigeria. Proceedings of C.I.G.R.Inter Sections Symposium.Ilorin-Nigeria

UNDP 1977. International Colloquim of Mayors on Governance and Equity New York City http.www/fao.org/unfaol/loodoes/cong.15x0076e.htm Retrieved6/6/2006.

Table 1: Background of respondent

S/N	Attribute	Percent score Enugu	Nsukka
A	Sex		
1	Male	51	48
2	Female	49	52
B	Marital Status		
1	Married	65	69
2	Single	34	31
3	Divorced	1	-
C	Occupation		
1	Civil Servant	30	34
2	Traders	06	10
3	Disengaged/retired civil servants	64	56
D	Educational Level		
1	Below FSLC	2	21
2	FSLC and Equivalent	43	39
3	WASC/Equivalent	40	30
4	Above WASC	15	10
E	Age in Years		
1	Below 20	6	10
2	21 – 40	14	10
3	41 – 60	55	58
4	Above 60	25	22

Table 2: Location, Types of Farm Activity and Specific Enterprise in the Two Cities

	Location of agricultural enterprise	Type of enterprise	Specific Enterprise	Type of power system
1	Ranks of River Ekulu from Onyeama Mine through Abakpa Nike and Thinker's Corner to NNPC Depot, Emene Enugu	Crop production	Vegetables, maize and cassava	Manual only
2	Sides of Enugu Port Harcourt road from Onyeama hill to Naira Triangle and then to Emene Enugu	Crop production	Vegetables, maize and cassava	Manual only
3*	Roads sides from Nowas Petrol Station to Abakpa and through Nike Road to Nike Lake	Crops production, ornamentals and nursery	Vegetables, palm seedlings, flower, etc	Manual
4*	Roadsides from Otigba junction to Artisan market	Crop production	Vegetable and maize	Manual
5*	Right hand side of the road from	Crop production	Cocoa yam,	Manual

	Location of agricultural enterprise	Type of enterprise	Specific Enterprise	Type of power system
	New Market to the Cemetery		vegetables & maize	
6	Open spaces between IMT Campus three and UNEC Enugu	Crop production	Cassava and maize	Manual
7	Foot of Miliken Hill Enugu	Crop production	Vegetables and maize only	Manual
8*	Right hand side of the road from ESBS Radio to ESUT	Crop production	Cassava, maize, and palm plantation	Manual
9	Prisons staff quarters at Kingsway Road Enugu	Crop and livestock production	Cassava, maize, vegetables, poultry and Goattery	Manual
10*	Obukpa Layout, Nsukka	Crop production	Cassava/maize	Manual
11	U.N.N. Staff Quarters	Livestock, Crop Production	Poultry, Vegetable, Maize	Manual
12	UNN Farm Centre (Experimental Plots)	Livestock, Crop production	Cattle ranch, vegetable, maize, pineapple, cassava	Manual
13	UNN Sewage	Crop production	Vegetable, Maize	Manual
14	Barracks and Ofulonu Areas of Nsukka	Livestock, Crop production	Poultry, Vegetable and maize	Manual
15	Prisons staff quarters Enugu	Crop and livestock production	Cassava, maize, vegetables, poultry	Manual
16	Ariaria market Enugu	Livestock, crop and food processing	Piggery, grains, goat, tomatoes meat etc	Manual, mechanical, electrical
17	Federal Department of Rural Dev. Onitsha Road Enugu	Crop production	Maize, cassava and vegetables	Manual
18*	From Onyeama Mine to New Market	Waste recycling, crop production	Poultry manure, maize, vegetables,	Manual
19	Ogbete Main Market Enugu	Livestock and Crop processing	Cow, grains, tomatoes	Manual/ mechanical
20^{+}	Government Reserved Areas. Court premises, prison areas and Local Government Office areas at Nsukka	Crop production	Vegetables, maize and cassava	Manual
21	Government Reserved Areas in parts of Enugu.	Food processing, and livestock	Grains, tomatoes, breadfruit, maize	Mechanical, Electrical

	Location of agricultural enterprise	Type of enterprise	Specific Enterprise	Type of power system
		production, crop production.	poultry, vegetables,	
22	Artisan Quarters Enugu	Crops production	Vegetables	Manual
23	Tributaries of Nike Lake at Nike, Enugu	Crop production	Vegetable only	Manual
24	Banks of Ava stream running from Nike Lake through Abakpa, Harmony Layout phases I to III, Emene into Enugu end of river Ebonyi	Crop production	Vegetables only	Manual
25+	Banks of the stream from Okpara Mine through, Ogbete, Ogui, Ama Hausa, Asata, NNPC Mega, Emene into Enugu end of river Ebonyi	Crop production	Vegetable, maize, cassava.	Manual
26+	Open spaces in the Railway Quarters Enugu	Crop production	Vegetables, cassava, maize	Manual
27+	Open spaces at the Police Depot and Shootjng range in Enugu	Crop production	Vegetables, cassava, maize	Manual

- Existed in the previous studies but area taken over by urbanization and infrastructural development

+ Existing but not covered in the previous studies



Fig. 1 Avegetable farm at Antisan Quarters, Enugu

Table 3: Type of Agricultural Enterprise

S/N	Attribute	Percent score	
A	Agricultural Enterprise	Enugu	Nsukka
1	Crop Production	35	39
2	Livestock production	23	26
3	Waste recycling/management	05	-
4	Processing (meat, crop, etc)	17	20
5	Storage	11	10
6	Others	09	05
B	Type of Crop Production	Enugu	Nsukka
1	Vegetable	48	55
2	Fruits	02	05
3	Cassava	10	06
4	Maize	37	32
5	Yam	02	01
6	Others	01	01
C	Types of processing	Enugu	Nsukka
1	Timber	03	04
2	Fruits	20	25
3	Grain	36	31
4	Cassava	15	15
5	Vegetable	06	03
6	Meat	20	22
C	Type of storage	Enugu	Nsukka
1	Tubers	01	02
2	Grains	60	18
3	Fruits	-	-
4	Palm Oil	24	39
5	Vegetable	-	-
D	Type of livestock	Enugu	Nsukka
1	Poultry	70.1	69.8
2	Fishery	1	-
3	Piggery	20.50	19
4	Goatery	9.40	11.20

Table 4: Types of practice (tillage and soil management system)

S/N	Attribute	Percent Score	
	Agricultural practice	Enugu	Nsukka
1	Mechanized harrowing	03	-
2	Mechanized ridging	-	-
3	Rotavating	-	-

4	Mulching	03	-
5	Chemical fertilizer	20	18
6	Human faeces	09	22
7	Plant residue	03	07
8	Poultry manure	62	53

Table 5: Ownership of Resources

S/N	Attribute	Percent Score	
		Enugu	Nsukka
A	Land		
1	Self	05	10
2	Government	15	08
3	Cooperative society	-	-
4	Company	-	-
5	Private individual	80	82
B	Water		
	Self	-	-
B	Government	10	05
1	Cooperative Society	-	-
2	Company	-	-
C	Power (Mechanical)		
1	Self	22	22
2	Government	14	-
3	Cooperative society	-	-
4	Company	09	
5	Private individual	55	78

Table 6: Awareness Index

S/N	Attribute	Percentage Score	
		Enugu	Nsukka
I	Existence of urban farming	100	100

DEVELOPMENT OF HAND PUSH MECHANICAL WEEDER

Muhammad, A.I. and Attanda, M. L.

Department of Agrcultural Engineering, Bayero University Kano, Nigeria.
alico079@gmail.com

ABSTRACT

A hand push mechanical weeder that consists of two sets of cone rotor blades, adjustable main frame and a float was developed from locally sourced materials. The weeder, of effective field capacity of 0.357 ha/hr has 64.87 N draft and overall width and depth of cut of 180mm and 20mm respectively. With a single runs of cut in between the rows on the field at a soil moisture content of 40.8%, the optimum weeding efficiency was 84.5% while weeding efficiency at 10.5% soil moisture content was 53.1%. Consequently, the highest plant damage of 8.33% was recorded at the 10.5% soil moisture content.0.058hp is the power required by a single person to push the prototype of the weeder

KEYWORDS: Weeding, Cutting depth, Effective width of cut, Field Capacity

1. INTRODUCTION

Weeds are plants growing where they are not wanted. Weeds tend to thrive at the expense of more refined crops. They provide competition for space, nutrient, water and sunlight (Kwesi and Datta 1991). Weed infestation on Nigerian soils is quite high, particularly during the raining seasons when soil moisture is high and plant growth conditions are optimum. The higher competitive nature of weeds compared to crops is posing serious threat to crop yield. Biswas*et al*, (1999) have shown that weeds cause between 50 to 70% reductions in crop yields.

According to Nganilwa et al, (2003) in Olukunle and Oguntunde, (2006) opined that a farmer using only hand hoe for weeding would find it difficult to escape poverty, since this level of technology tends to perpetuate human drudgery, risk and misery. Management of weeds is an important component of production techniques as elimination of weeds is expensive and hard to achieve (Olukunle and Oguntunde, 2006). The methods employed to remove weeds on the farm include flaming, desiccation, manual, chemical and mechanical weeding. However in the recent times the problem of environmental degradation and pollution is making the world to have a re-think on the adoption of mechanical weeders.

Manual weeding is common in Africa particularly in Nigeria where about 75 % of the population is engaged in farming. This method is labour intensive and is one of the major problems of farming in Nigeria. The resultant effect is that youths detest farming and engage in rural- urban migration in search of greener pastures. Therefore, in order to increase the productivity per unit area of small land holdings and considering the economic condition of Nigerian farmers, it is quite necessary to have suitable agricultural equipment which farmers can use and also allow for custom hiring. To achieve this, a mechanical hand push weeder was developed and performance parameters evaluated, at the experimental plot ofBayero University, Kano.

2. MATERIALS AND METHODS

2.1 Description of the Weeder

The mechanical weeder is a manually operated machine which consists of frames made from hollow pipes of different diameters. The mechanical weeder has two conical rotors mounted in tandem with opposite orientation. Smooth and serrated blades mounted alternately on the rotor that uproot and burry weeds because the rotors create a back and forth movement in the top 3 cm of soil (fig.8). The weeder is expected to satisfactorily weed in a single forward pass without a backward movement. The components of the orthographic views of the weeder is shown in fig. 9

2.2 Material Selection and Components parts of the Weeder

The main frame was constructed from circular hollow pipes (25mm diameter) with an adjustable length of 2140 mm. Another pipe of same diameter was welded to the frame, with brackets of 145mm length to hold the cones on to which the blades were mounted, (Fig.3).The handle was made of hollow circular steel pipe of 25mm diameter and length of 400mm, (Fig. 3). The rotating cones were constructed from 2mm sheet of metal with diameters of 100mm and 50mm for outer and inner section of the cone respectively and 10mm for bolts' hole,(fig.4). The arrangement of the cones was such that cutting was done progressively, one cone after the other.

Cone brackets: There are two pairs of cone brackets of 145mm lengthattached to the L-shaped frame with the help of bolt and nuts that supports the cones. They are made from hollow pipe of 16mm diameter,(fig. 5).There are two sets of the cutting blades mounted on the cones as shown in fig.6. Each cone has twelve blades out of which six are serrated and are arranged in circular planes of the cone at an angle 30^{o} to each other. The blades were made of steel of 140 x 35mm in length and width and 1.5mm thickness and are welded to the circular surface of the cone of 100 mm diameter that carries a centre-hole of 10 mm diameter for the cone shaft. The cutting edge of the blades was bevelled as shown in fig.6 at an angle 92° to minimize the effort required in cutting the soil.A float is in front of the weeder blades whose function is to control the depth of soil cut, parking and stability when the weeder is working. The float is also capable of pressing the weeds in the horizontal direction; this is to allow the blades to cut the weeds easily. It was constructed using a 1mm sheet of metal of dimensions to give required shape and size, (Fig.7).

2.3 Design Consideration

The following factors were considered in the development of the weeder;

- the density and the condition of weed
- soil physical characteristics (Soil moisture content, bulk density)
- the characteristics of the interface between soil and the soil acting elements of the weeder
- Soil-implement interface (width of cut, depth of cut, soil cohesion).

2.4 Design Parameters

The design parameters that influence the development of the weeder are discussed below.

TheWorking Width was determinedas the distance between the extreme ends of the cone rotors with steel rule or tape.

The forward speed was determined as

$$\text{Average Speed} = \frac{\text{Distance (m)}}{\text{----------}} \quad (1)$$

Time (sec)

The draft of the weeder can be calculated as

D = W x dw x Rs ---------- (2)(Yadav and Pund,2007)

Where,

D – Draft of the weeder, (N)

W- Width of cut (cm)

dw – Depth of cut (cm)

Rs – Soil resistance (Kg/cm^2)

Power required to push the weeder

$$\text{Power (kW)} = \frac{\text{draft force (N) x speed (m/s)}}{1000} \text{ ---------- (3)}$$

(Yadav and Pund, 2007)

1KW = 1.341hp

2.5 Determination of Soil parameters

2.5.1 Soil Moisture

The moisture content of the test farm was determined at various locations within the farmusing a digital moisture content meter placed at soil depth of 0.2cm.

2.5.2 Soil Resistance, Rs

This is the average penetration resistance of the soil to implement,given by the relation below:

$$Rs = \frac{\text{weight of weeder}}{\text{Total Area of Weeder in Contact with the soil}}$$

$$Rs = \frac{\text{weight of weeder}}{(2x\ L\ x\ B) + (L_f\ x\ B_f)}\ Kg/cm^2$$ (Yandav and Paul, 2007)

Where, L = Length of weeder blade(cm)

B = thickness of weeder blade (cm)

L_f = length of weeder float (cm)

B_f = breadth of float (cm)

Weight of weeder (Kg)

2.6 Experimental Field

The weeding test was carried out at Agricultural Engineering Departmental Research and Demonstration Farm of the Bayero University, Kano ( ) on to which wheat was sown 2009-2010 planting season according to standard cultural practice.

2.7 Performance Evaluation

2.7.1 Weeding efficiency

The weeding efficiencies at different moisture condition were calculated using the equation below:

$$E_w = \frac{W_1}{W_1+W_2} \times 100$$ ---------- (4) (Manuwa et. al, 2009)

Where:

E_w = Weeding efficiency (%)

W_1 = Weight of cut weeds (g)

W_2 = Weight of survived weeds (g)

2.7.2 Effective field capacity (FC_E)

$FC_E = W_a \; x \; E_w \; x \frac{10^4}{3600} \; (ha/hr)$ ---------- (5)

Where:

FC_E = Effective field Capacity (ha/hr)

W_a = Effective weeding width (m)

E_w = Weeding efficiency (%)

2.7.3 Theoretical field capacity

Theoretical field capacity (FC_T) is calculated from the *mean* values of working width and working speed

FC_T = *working width* × *mean speed* ---------- (6)

2.7.8 PercentagePlant Damage

Percentage Plant Damage = $1 - \frac{q}{p} \; x \; 100$---------- (7)

Where, q = Number of plants in a 3 m row length after weeding

p = Number of plants in a 3 m row length before weeding

3. RESULTS AND DISCUSSION

3.1 Effect of Soil Moisture on Cutting efficiency

The weeding efficiency at different moisture content of the soil was found to be in the range of 53.1% to 84.5% as shown in fig. 1.It was observed that the highest weeding efficiency of 84.5% was obtained with developed mechanical weeder at 40.8 % moisture content, this may be due to the reason that minimum soil-weed interface force occurred at this moisture content. Then followed by 79.3%, 76.7%, 74.0%, 60.8%, 53.1% at 32.5%, 29.5%, 23.7%, 18.1%, 10.5% soil moisture contents respectively. The least weeding efficiency, 53.1% was found at moisture content of 10.5% and this may be due to higher hardness of soil with this moisture content. This shows that from fig. 1, the cutting efficiency decreases as the soil moisture decreases.

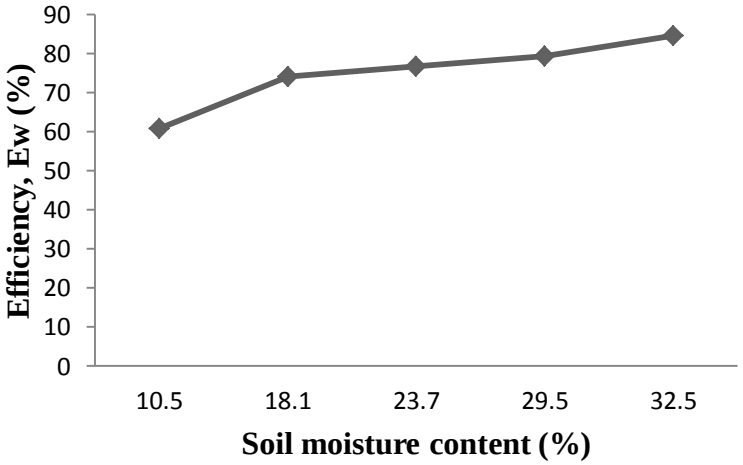


Figure 1: Effect of Soil Moisture on Cutting efficiency

3.2 Effect of Soil Moisture Content on Plant Damage

From figure 2, it was found that the lowest percentage of plant damage of 5.26% was observed at 40.8% moisture content. The highest percentage of plant damage of 8.33% was observed at 10.5% moisture content. The plant damage increased with decrease in moisture content. This may be due to the reason that with decrease in moisture content of the soil, soil hardness increases and as a result, weeding elements could not penetrate to the desired depth and sometimes skid over hard surface and strikes the plant.

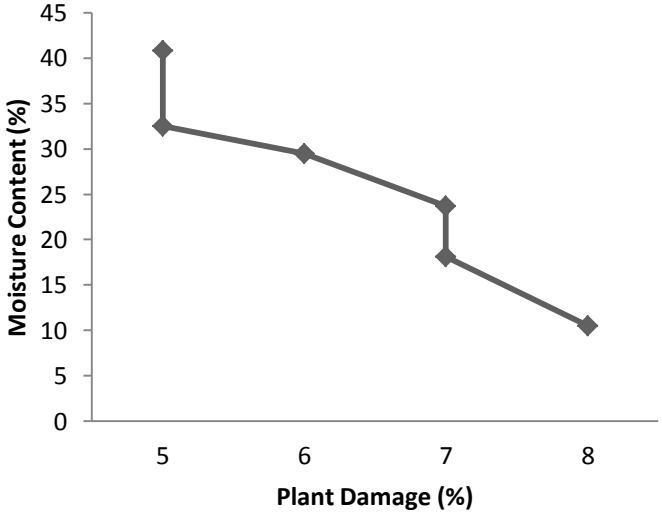


Figure 2: Effect of Soil Moisture on plant damage

4. CONCLUSION

The developed hand push mechanical weeder is easy to operate and require no maintenance skill or practice. The weeder could work up to 0.2 cm depth and with an adjustable width of 18cm at field capacity of 0.357 ha/hr at different soil moisture. The weight of the developed weeder was 4.5Kg thus suitable to be operated by one person and could be affordable by most peasant farmers.

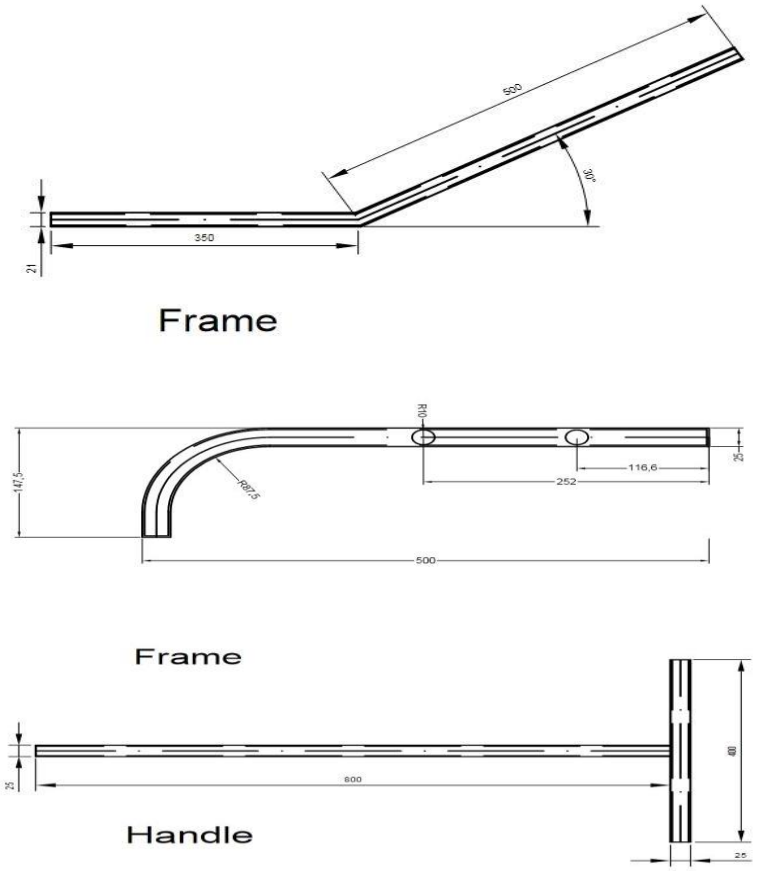
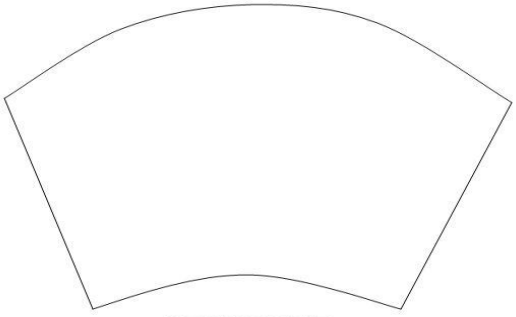


Figure 3: Main frame and Handle



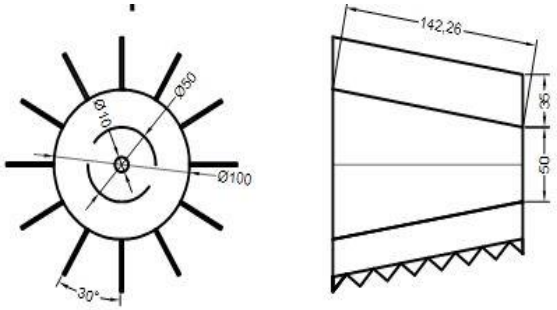


Figure 4: Cone and Blades

FRONT **SIDE** *All dimensions in mm*



Figure 5: Cone Brackets

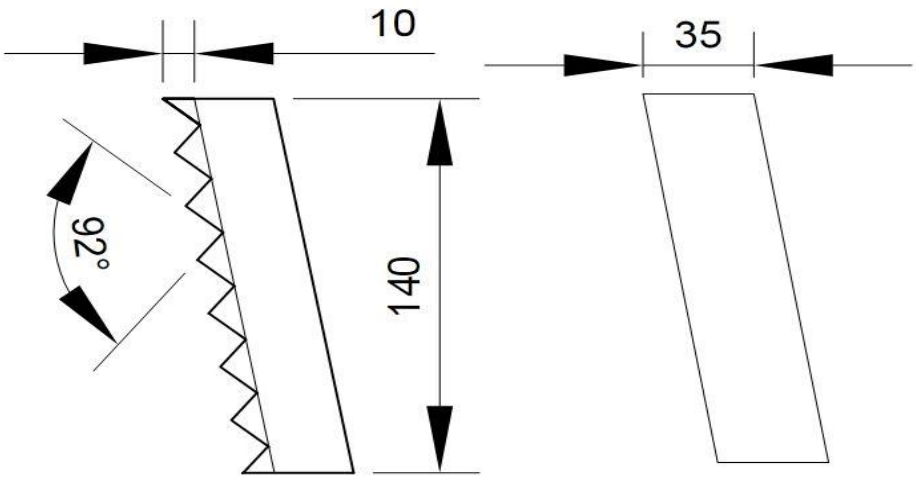


Figure 6: Cone Brackets and Blades

All dimensions in mm

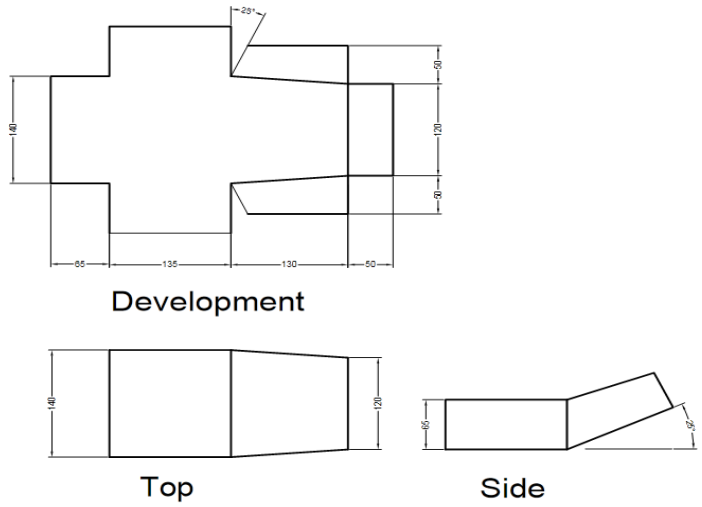
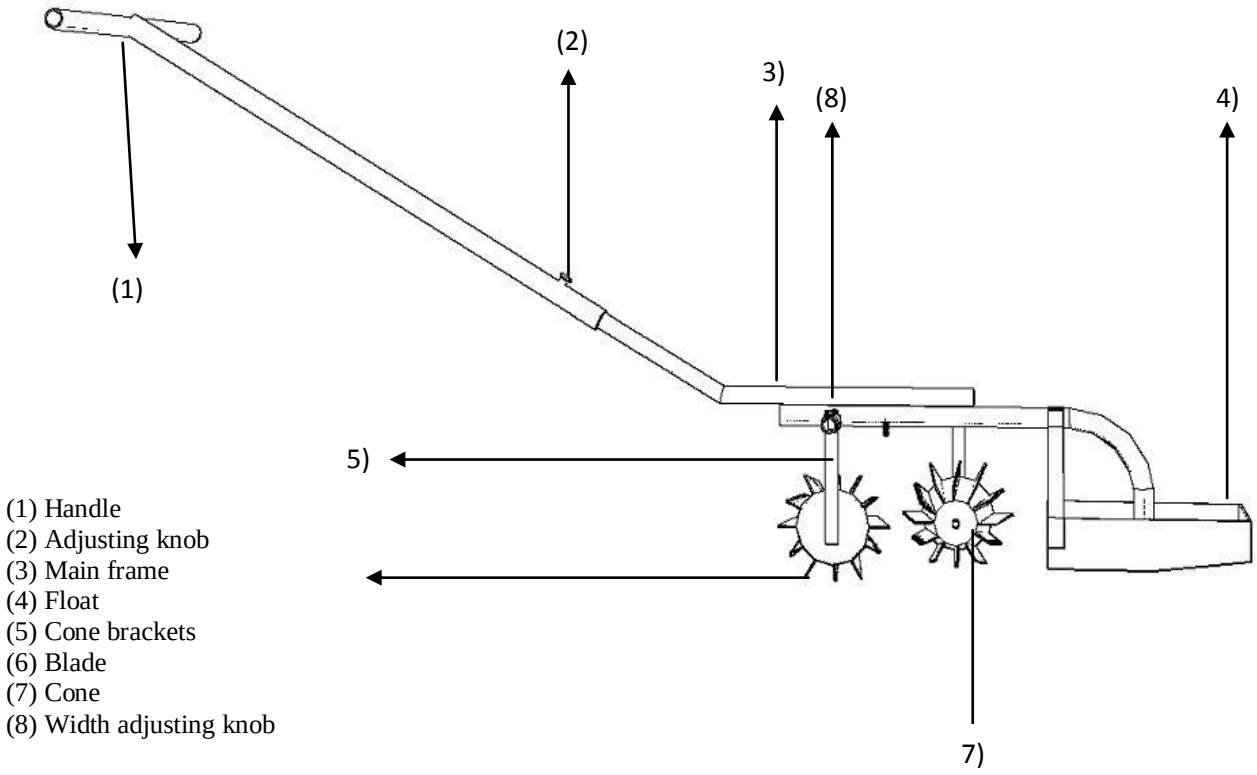
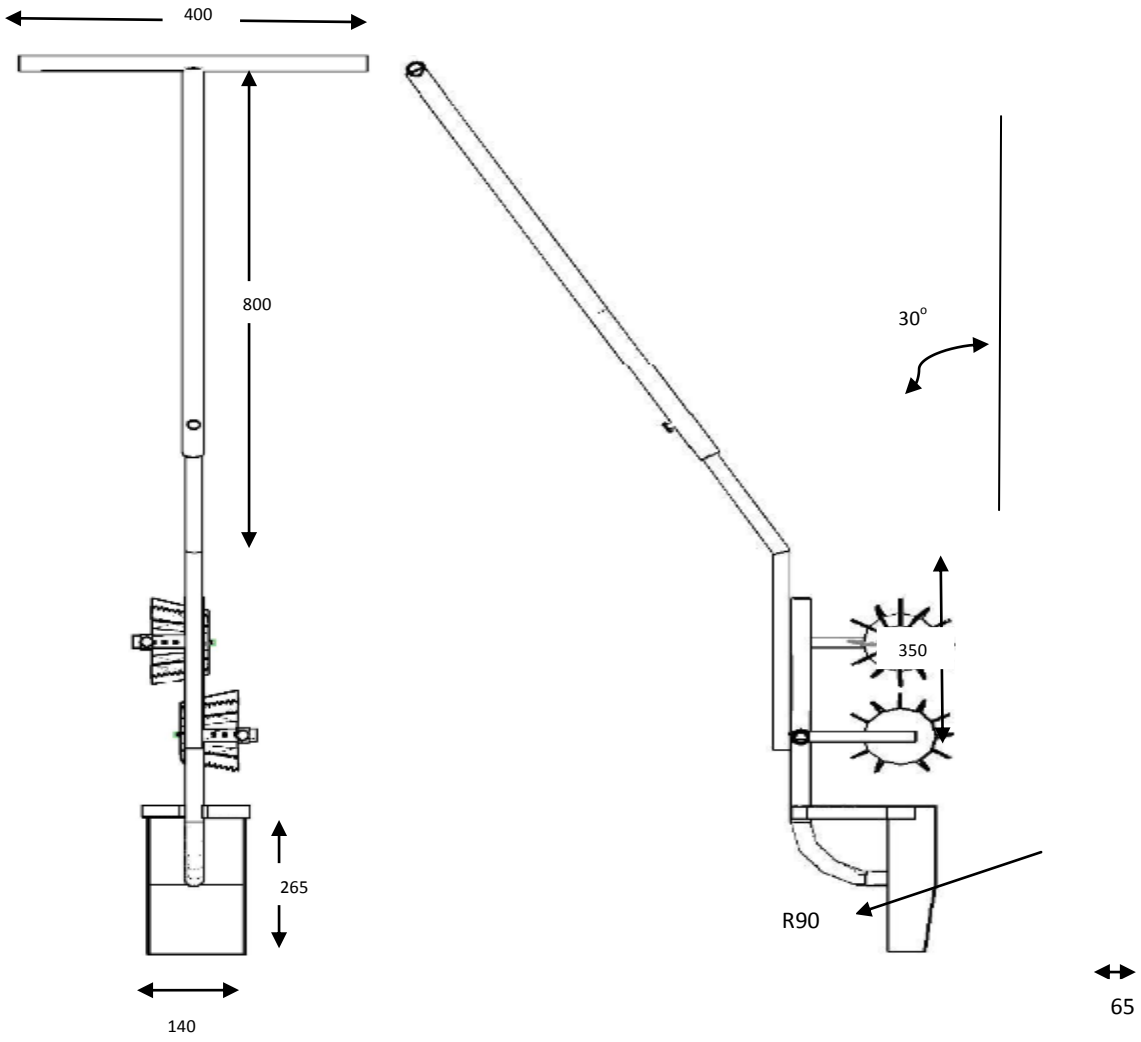


Figure 7: Float

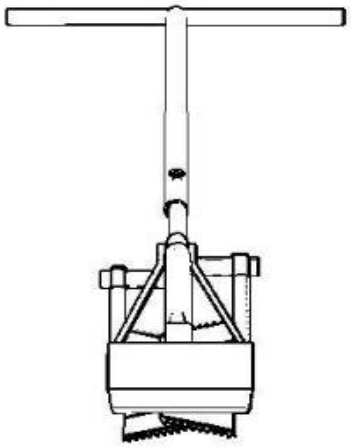


(1) Handle
(2) Adjusting knob
(3) Main frame
(4) Float
(5) Cone brackets
(6) Blade
(7) Cone
(8) Width adjusting knob

Figure 8: Mechanical weeder



Plan View **Side View**



Front View

Figure 9: Orthographic views of the weeder

All dimensions in mm

REFERENCES

Ashburner J. E. and Sims B. G. (1984).*Elementos de diseñodel tractor y herramientas de labranza.*InstitutoInteramericano de Cooperaciónpara la Agricultura,San José, Costa Rica.Pg. 12.

Biswas, H.S., T. P. Ojha and G.S. Ingle.(1999). Development of animal drawn weeders in India.*Agricultural Mechanization in Asia, Africa & Latin America* 30(4): 57-62.

Busari, L.D. (1996). Influence of Row Spacing on Weed Control in Soybean in Southern Guinea Savannah of Nigeria.*Journal of Weed Science* 10:17-23

Fornstron, K. J., R. D. Brazee and W. H. Johnson, (1970).Tillage – Tool Interaction with a Bounded, Artificial Soil. Transaction of the ASAE, 13(4): 409-416.

Hendrick, J. G. and W. R. Gill, (1971). Rotary Tiller Design parameters. Transaction of ASAE, 14(4): 669 – 674; 683.

Kwesiampong-Nyarko and S. K. Datta (1991).A Handbook of Weed Control in Rice. International Rice Research Institute. Manila, Philipines.

Kepner, R. A., R. Bainer and E. R. Barger, (1972). Principle of Farm Machinery, The A. V. I. Publishing Company, Inc., West Port, Connecticut, pp. 131.

Nganilwa Z.M, Makungu P.J and Mpanduji S.M (2003). Development and Assessment of an Engine Powered Hand Held Weeder in Tanzania. International Conference on Industrial Design Engineering, UDSM, Dares Salam.

Olukunle, O. J. and Oguntunde, P. (2006).Design of a Row Crop Weeder.*Proceedings of aConference on International Agricultural Research for Development held at University of Bonn.*GermanyTropentag, Pp 1-4.

Rangasamy, K. Balasubramanian, M and Swaminuthan, K.R. (1993).Evaluation of Power Weeder Performance. AMA 24 (4) : 16-18

R. Yadav and S. Pund "Development and Ergonomic Evaluation of Manual Weeder". Agricultural Engineering International: the CIGR Ejournal. Manuscript PM 07 022. Vol. IX. October, 2007

S.I. Manuwa, O.O. Odubanjo, B.O. Malumi and S.G. Olofinkua (2009).'Development and Performance Evaluation of a Row-Crop Mechanical Weeder'.*Journal of Engineering and Applied Sciences*, 4(4), Pp. 236-239.

DEVELOPMENT OF MODEL FOR PREDICTING YIELD OF MAIZE USING PLANT HEIGHT, MEAN EMERGENCE DATE, MEAN EMERGENCE RATE AND EMERGENCE RATE INDEX

Abdulkadir Salihu Ahmed and Shehu Adamu Iya

Department of Agricultural Engineering, College of Engineering Technology, Adamawa State Polytechnic, Yola
Department of Agricultural and environmental Engineering, School of Engineering and Engineering Technology, Modibbo Adama University of Technology, yola

ABSTRACT

Planter type, maintenance, and operation play an important role in uniform stand establishment in Maize (Zea mays L.). Research was conducted to determine if planter type(Monosem pneumatic planter and Parmiter mechanical planter) affects Maize yield by applying different tillage system (Conventional tillage, reduced tillage, Minimum tillage, and No-tillage) with 10cm with in row plant spacing and to determine if planting speed and tillage influence these effects. This experiment was performed at Mbilla farms limited in Mayo-belwa local government area of Adamawa state, Nigeria. Result of mean treatments interaction were statistically analyzed using simple and multiple linear regression analysis to determine the coefficients of correlation showed that some parameters measured were significant at 5% ($p>0.05$), while some did not show significant difference at 5% level of probability ($p = 0.05$) respectively. A simple linear correlation showed that for parmiter mechanical planter, all the parameters where significant except plant height with correlation coefficient of $r = 0.58, 0.86, 0.89$ for spacing, ERI, MED and $r = 0.05$ for plant height. While that of Monosem pneumatic planter with correlation coefficient of $r = 0.34, 0.98, 0.96$ for plant height, ERI, MED and are all significant while for spacing $r = 0.06$ and was not significant. A multiple linear correlation of relation between yield and all other parameters gave a coefficient of 0.134,0.0053,0.076 and 0.106 for height, MED, ERI, and Spacing. Treatments were established with conventional tillage (CT) and Reduced tillage (RT), Minimum tillage (MT), No-tillage (NT) as main plots, two planter types (Parmiter mechanical planter and Monosem pneumatic planter) as subplots, and two planting speeds of 7.2 and 11.3 km per hour (km/h) as sub-subplots. Planter type affected stand uniformity with mean plant height of 51.21cm, 54.28cm, mean within-row plant spacing of 10.54cm, and 10.26 cm, mean emergence date (MED) of 13.58d and 13.11d emergence rate index of 11.43d and 13.75d, mean yield of 5.40t/ha and 6.00t/h for Monosem pneumatic planter (MPP) and Parmiter mechanical planter respectively.

1. INTRODUCTION

Excessive planting speed can alter seeding rates, increase stand establishment variability, and consequently decrease grain yield. Increasing planting speed increased the standard deviation of plant spacing. Nielsen, (1995b) reported a decrease in plant population at 1 of 22 sites and an increase at 9 of 22 sites, and that faster planting speeds can decrease uniformity of seeding depth and affect seed-to-soil contact, causing uneven emergence, and concluded that future planter speed studies should go beyond measuring uniformity of seed placement (depth and spacing) and include a measure of emergence uniformity.

Spacing uniformity, timing and rate of emergence, plant population and maize stand are the most common characteristics used by producers in assessing or evaluating planter

performance. Seed metering mechanism and maintenance along with planting speed of a planter may all influence seed singulation and placement and can further affect plant spacing and emergence variability, which may ultimately affect plant growth and grain yield, (Liu et al., 2004a). The effect of planter speed on final plant density makes evaluating the impact of variations in plant spacing a difficult task. Vanderlip et al., (1988) reported that plant spacing variability gave a considerable yield while maintaining a constant plant density through hand thinning. Nielsen (1995a) reported that the effects of planter speed might have been confounded by plant density and did not account for the influence of multiples or misses on corn yields, whereas Nafziger (1996) reported that multiple plants can increase yields by approximately 6% whereas misses can decrease yields by as much as 7%.

Soil tillage is among the important factors affecting soil physical properties and crop yield. Among the crop production factors, tillage contributes up to 20% (Khurshid et al., 2006). Tillage method affects the sustainable use of soil resources through its influence on soil properties (Hammel, 1989). The proper use of tillage can improve soil related constrains, while improper tillage may cause a range of undesirable processes, example. destruction of soil structure, accelerated erosion, depletion of organic matter and fertility, and disruption in cycles of water, organic carbon and plant nutrient (Lal, 1993). Use of excessive and unnecessary tillage operations is often harmful to soil. Therefore, currently there is a significance interest and emphasis on the shift to the conservation and no-tillage methods for the purpose of controlling erosion process (Iqbal et al., 2005).

This study is very important in the sense that most of the machinery that are imported into the country are not tested and certified for our environments even though , there is a Government parastatal vested with that responsibility. Thus the study will enable farmers and government alike to know the kind of planters that will be suitable for our environment and has required performance efficiency. The objective of this study is to develop a simple linear and multiple linear regression models to predict yield base on plant height, mean emergence date (MED), emergence rate Index (ERI), and plant spacing for monosem pneumatic planter and parmeter planter and the combination of both the planters.

2. MATERIALS AND METHODS

The Farm is located within Latitude $9^{o}3^{1}$north and Longitude $12^{o}\ 3^{1}$East at an Altitude of 158.5m with in the Northern guinea Savannah zone of Nigeria. Rainfall commences in April and last till October, while harmattan starts from November to February, the average minimum rainfall ranges from 770mm to 1600mm (Adebayo and Tukur, 1999).

2.1. Seedling Emergence.

Plant emergence was recorded by daily counting the number of emerged plant in randomly selected rows of each sub-subplot which commenced seven (7) days after Planting and the counting continued for the next thirty (30) days. Maize emergence rate was counted for several days at each plot during the mean emergence date (MED) in four (4) rows.

The emergence rate index (ERI) was calculated directly from emergence counts as follows (Nasr and Selles, 1995; Carman, 1997; Mohanty and Painuli, 2004):

$$\mathrm{MED} = \frac{\mathrm{N_1}.\mathrm{D_1} + \mathrm{N_2}.\mathrm{D_2} + \cdots + \mathrm{N_n}\mathrm{D_n}}{\mathrm{N_1} + \mathrm{N_2} + \cdots + \mathrm{N_n}} \quad (1)$$

$$\mathrm{ERI} = \frac{\mathrm{T}otal\ \mathrm{Number\ of\ emerged\ plant}}{\mathrm{MED}} (2)$$

Where $N_1, N_2 \ldots\ldots N_n$ = The increase in the number of newly emerged plant stems compared with the previous count.
And $D_1, D_2 \ldots\ldots\ldots D_n$ = Number of day after planting.

2.2. Yield

The crop was harvested from each plot of 3.0m × 4m when the grains were matured and dry and sun dried to reduce the moisture content and the grains were separated from the stalk by threshing manually and the weight measured and converted to tonne per hectare.

2.3. Plant Heights

Heights of 20 randomly selected plants from each plot were measured at 10, 20, and 30 days after seedling emergence using a meter rule from point of emergence to emergence after 30 days and mean plant height was obtained for each plot.

2.4. Statistical Analysis

Analyses of variance for a split-split plot design were performed All treatment factors in the experiments were considered as fixed effects with the locations, and blocks were treated as random effects. To determine the mean effect between treatments, mean comparison was performed using Duncan Multiple Range Test (DMRT) comparisons. Linear Correlation was performed to determine the relationship between plant height, spacing, emergence rate indexes (ERI), Mean Emergence date (MED), on grain yield. Multiple linear correlations were also performed for yield and plant height, spacing, emergence rate index (ERI), Mean Emergence date (MED).
The experimental design used was the split-split plot arrangement of a randomized complete block with three replicates of each treatment. The split plot design is used because the following:
1. Three plot sizes corresponding to the three factors; namely, the largest plot for the main factor, the intermediate size plot for the subplot factor, and the smallest plot for the sub-subplot factor.
2. There are three levels of precision with the main plot factor receiving the lowest precision, and the sub-subplot factor receiving the highest precision. Gomez (1984b)

Four tillage systems were taken as the main plots (Conventional tillage, reduced tillage, Minimum tillage, No-tillage), two types of planters (Parmiter Mechanical planter and Monosem Pneumatic Planter) were used as subplots, and two levels of planting speed (7.20km/h and 11.30km/h) were used as the sub-subplots treatments. Each sub-subplot consisted of four rows having 0.76-m row spacing with 25m length. Each main plot had 0.76-m row spacing and 25m length. The treatment combinations used were the tillage system, planter type, and planter speed and it gave a total of sixteen (16) treatments levels. The tillage systems were; Conventional Tillage (CT), Reduced Tillage (RT), Minimum Tillage (MT) and No Tillage (NT), which gave the total number of 16 main plots as shown in table 3.1 and fig 3.1 below, tillage, planter type, Monosem pneumatic planter (MPP) and Parmeter mechanical planter (PMP) and planter speed (S_1=7.2km/h and S_2=11.30km/h) abbreviation showing the randomized split-split plot design for the research.

The two planter types are used in the experiment because they are the only available planters that are available are been used presently in the research environment. The speed 7.20km/h and 11.30km/h as the minimum and the maximum speed of corn planting according to Jasa and Dickey (1982).The randomization of the treatment is to minimized error and minimizing error will give precision to the research work.

Analyses of variance for a split-split plot design were performed All treatment factors in the experiments were considered as fixed effects with the locations, and blocks were treated as random effects. Linear Correlation was performed to determine the relationship between plant height, spacing, emergence rate indexes (ERI), Mean Emergence date (MED), on grain yield. Multiple linear correlations were also performed for yield and plant height, spacing, emergence rate index (ERI), Mean Emergence date (MED).

3. RESULTS AND DISCUSSION

A linear correlation between plant height and yield, shows the linear correlation models equation 3 below within a range of 48.90cm - 53.60cm and correlation model equation 4 within a range of 52.60cm - 56.10cm for both Monosem pneumatic planter (MPP) and Parmiter mechanical planter (PMP), at all combinations from table 2 above.

$$\boldsymbol{y = 2.26 + 0.050 height_{PMP}} \quad 3$$

$$\boldsymbol{y = -1.17 + 0.121 height_{MPP}} \quad 4$$

$y = yieild$(t/h).

$height_{\mathrm{PMP}} = heightforparmitermechanicalplanter$(cm).

$height_{\mathrm{MPP}} = heightforMonosemPnuematicplanter$(cm).

Similarly, the correlation coefficient $\mathbf{r = 0.02, 0.34}$ for both the two (2) planter and the treatment combination were both not significant with relation to mean plant height because the value of the calculated coefficient 0.02, 0.34(**r-calculated)** is less than the tabular correlation coefficient(**r- tabular)** which impliedly shows that the correlation coefficient under plant height for all treatment combinations were not significant as shown in Table 2 below.

Linear Correlation graph as shown in Fig 1(a) and Fig 1(b) shows a linear correlation relation between maize plant height and yield for both Monosem pneumatic planter (MPP) and Parmiter mechanical planter (PMP) with the treatment combinations of tillage systems and planter speed levels. The graph shows that there is a direct correlation relationship between plant height and yield, as the plant height increases the yield also increases with regards to relationship between variables observed.

A linear correlation between yield and mean emergence date (MED), shows the linear correlation models, equation 5 below within a range of 13.20days – 13.90days and correlation model, equation 6 within a range of 12.90days – 13.50days for both Monosem pneumatic planter (MPP) and Parmiter mechanical planter (PMP), at all combinations from table 2 above.

$$\boldsymbol{y = 1.54 + 0.25 MED_{PMP}} \quad 5\boldsymbol{y}$$

$$\boldsymbol{= 25.79 - 1.54 MED_{MPP}} \quad 6$$

Similarly, the correlation coefficient $\mathbf{r = 0.89, -0.96}$ for both the two (2) planter and the treatment combination were both significant at 5% level of significance with relation to average mean emergence date because the value of the calculated coefficient 0.89, 0.96(**r-calculated)** is greater than the tabular correlation coefficient(**r- tabular)** which impliedly shows that the correlation coefficient under mean emergence date (MED) for all treatment combinations were significant at $P < 0.05$ as shown in Table 4.3 above.

Linear Correlation graph as shown in Fig 2(a) and Fig 2(b) shows a linear correlation relation between average Mean emergence date and yield for both Monosem pneumatic planter (MPP) and Parmiter mechanical planter (PMP) with the treatment combinations of tillage systems and planter speed levels. The graph shows that there is a

direct correlation relationship between plant height and yield, as the plant height increases the yield also increases with regards to relationship between variables observed.

A linear correlation between yield and emergence rate index (ERI) calculated and gave the linear correlation models in, equation 7 below within a range of 10.70days – 11.70days and correlation model, equation 8 within a range of 11.90days – 14850days for both Monosem pneumatic planter (MPP) and Parmiter mechanical planter (PMP), at all combinations from table 2 above.

$$\mathbf{y = 7.98 - 0.26ERI_{PMP}} \quad 7$$

$$\mathbf{y = 2.44 + 0.22ERI_{MPP}} \quad 8$$

Similarly, the correlation coefficient $\mathbf{r = 0.34}$, $\mathbf{-0.68}$ for both the two (2) planter and the treatment combination were both significant at 5% level of significance in relation to average mean emergence rate index because the value of the calculated coefficient 0.34, 0.68(**r-calculated)** is greater than the tabular correlation coefficient(**r- tabular)** which impliedly shows that the correlation coefficient under emergence rate index (ERI) for all treatment combinations were significant at $P< 0.05$ as shown in Table 2 above.
Linear Correlation graph as shown in Fig 3(a) and Fig 3(b) shows a linear correlation relation between average emergence rate index and yield for both Monosem pneumatic planter (MPP) and Parmiter mechanical planter (PMP) with the treatment combinations of tillage systems and planter speed levels. The graph shows that there is a inverse correlation relationship between ERI and yield in the parmiter mechanical planter, as the ERI increases the yield also decreases with regards to relationship between variables observed.

A linear correlation between yield and plant spacing calculated and it gave the linear correlation models in, equation 9 below within a range of 10.00cm – 10.60cm and correlation model, equation 10 within a range of 10.00cm – 10.60cm for both Monosem pneumatic planter (MPP) and Parmiter mechanical planter (PMP), at all combinations from table 2 above.

$$\mathbf{y = -16.24 + 2.013Spacing_{PMP}} \quad 9$$

$$\mathbf{y = 15.38 - 0.970Spacing_{MPP}} \quad 10$$

Similarly, the correlation coefficient $\mathbf{r = 0.59}$, for parmiter mechanical planter was significant at 5% level while correlation coefficient $\mathbf{r = 0.06}$, for Monosem pneumatic plant was not significant at 5% level of in relation to average mean spacing because the value of the calculated coefficient , 0.59(**r-calculated)** is greater than the tabular correlation coefficient(**r- tabular)** which impliedly shows that the correlation coefficient under Parmiter mechanical planter treatment combinations were significant at $P< 0.05$ as shown in Table 2 above.

The multiple linear correlation subjected to the data to obtain a model relating the yield and all other parameters considered gave a linear model and is given as;

$$\text{yield} = -3.87 + 0.134\mathbf{height} - 0.0053\mathbf{MED} + 0.076\mathbf{ERI} + 0.106\mathbf{Spacing}$$

A simple linear correlation showed that for parmiter mechanical planter, all the parameters where significant except plant height with correlation coefficient of $r = 0.58, 0.86, 0.89$ for spacing, ERI, MED and $r = 0.05$ for plant height. While that of Monosem pneumatic planter with correlation coefficient of $r = 0.34, 0.98, 0.96$ for plant height, ERI, MED and are all significant

while for spacing $r = 0.06$ and was not significant. A multiple linear correlation of relation between yield and all other parameters gave a coefficient of 0.134,0.0053,0.076 and 0.106 for height, MED, ERI, and Spacing.

The mean emergence and emergence rate index (MED and ERI) varied at thirty (30) days after emergence but after these, the growth was directly proportional after each day after 30 days of emergence. All parameter did not show much different in daily growth.

4. CONCLUSION

Planter type, tillage and planting forward speed has great influence on the growth and yield (output) of Maize.

REFERENCES

Adebayo, A. A. and Tukur A. L. (1999): Adamawa State in Maps. Paracllete Publishers Yola. (FUTY) Page 11 – 29.

Carman, K. 1997. Effect of Different Tillage Systems on Soil Properties and Wheat Yield in middle Anatolia. Soil and Tillage Res. 40: 201-207.

Gomez A. K. and Gomez A. 1984. Statistical Procedure for Agricultural Research. John Willey and Sons, New York pg 101.

Hammel J.E. 1989. Long Term Tillage and Crop Rotation Effects on Bulk Density and Soil Impedance in Northern Idaho. Soil Sci. Soc. Amer. J. 53: 1515-1519.

Iqbal M., Hassan A.U., Ali A. and Rizwanullah M. 2005. Residual Effect of Tillage and Farm Manure on Some Soil Physical Properties and Growth of Wheat (Triticum aestivum L.).Int. J. Agri. Biol. 1: 54-57.

Jasa, P. J., and E. C. Dickey. 1982. Tillage and planting Factors Affecting Corn Plant Spacing. Transactions of the ASAE 25(6): 1516−1519.

Khurshid K., Iqbal M., Arif M.S. and Nawaz A. 2006. Effect of Tillage and Mulch Soil Physical Properties and Growth of Maize. Int. J. Agri. Biol. 5: 593-596.

Lal R. 1993. Tillage Effects on Soil Degradation, Soil Resilience, Soil Quality and Sustainability. Soil and Tillage Res. 51: 61-70.

Liu, W., M. Tollenaar, G. Stewart, and W. Deen. 2004a. Within Row Plant Spacing Variability Does Not Affect Corn Yield. Agron. J. 96:275–280

Nafziger, E.D., P.R. Carter, and E.E. Graham. 1996. Response of Corn to Uneven Emergence. Crop Sci. 31:811–815.

Mohanty, M. and D.K. Painuli. 2004. Modelling Rice Seedling Emergence and Growth under Tillage and Residue Management in Rice-Wheat System on a Vertisol in Central India. Soil and Tillage Res. 76:167-174.

Nasr, H.M. and F. Selles. 1995. Seedling Emergence as Influenced by Aggregate Size, Bulk Density, and Penetration Resistance of Seedbed. Soil and Tillage Res. 34: 61-76.

Nielsen, R. L. 1995b. Planting Speed Effects on Stand Establishment and Grain Yield of Corn. J. Prod. Agric. 21: 119−123.

Vanderlip, R. L., J. C. Okonkwo, and J. A. Schaffer. 1988. Corn Response to Precision of Within−Row Plant Spacing. AppliedAgric. Res. 3: 116−119.

Table1. Treatments and their abbreviations as used in the Experimental design and Data analysis

Treatment(tillage systems)	Abbreviation	Description
Conventional tillage	CT	Disc plough + two (2) passes of disc harrow.
Reduced tillage	RT	Two (2) passes of disc harrow.
Minimum tillage	MT	One (1) pass of disc harrow.
No-tillage	NT	Direct planting but no tillage
Monosem pneumatic planter	MPP	Pneumatic planting method
Parmiter Mechanical planter.	PMP	Mechanical method of planting
Speed level 1	S_1	Planting forward speed of 7.20km/h
Speed level 2	S_2	Planting forward speed of 11.30km/h

Table 2 Linear correlations for effect of planter type, planting speed and tillage on plant height, spacing, emergence rate index, and mean emergence date

Planter	Independent Variable	Y Intercept	Slope	R	r^2
(PMP) Parmiter Mechanical planter	HT(48.9-53.6CM)	2.26	0.05	0.02	0.04
	SP(10.3-10.6CM)	-16.23	2.01	0.58**	0.34
	ERI(10.7-11.7d)	7.98	-0.26	-0.86**	0.74
	MED(13.2-1313.9d)	1.54	0.25	0.89**	0.79
(MPP) Monosem Pneumatic Planter	HT(52.6-56.10CM)	-1.17	0.12	0.34**	0.12
	SP(10.0-10.6CM)	15.38	-0.97	-0.06	0.30
	ERI(11.9-14.8d)	2.44	0.22	0.98**	0.96
	MED(12.9-13.5d)	25.79	-1.54	-0.96**	0.92

Source: Field test

HT plant heights, spacing, ERI emergence rate Index, MED mean emergence date significant.**

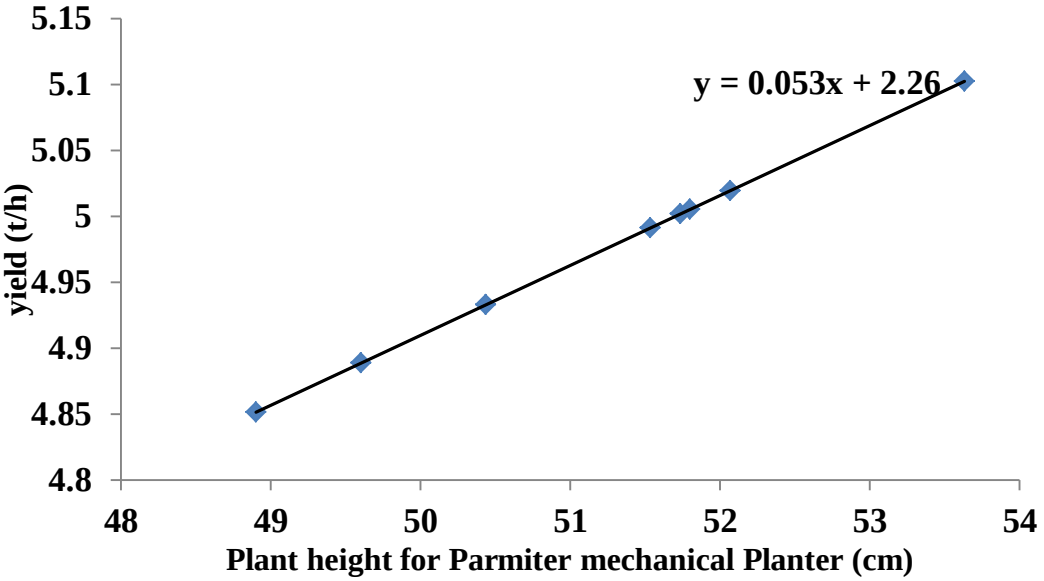


Fig 1a: Linear Relationship between Yield and plant height for Parmiter planter.

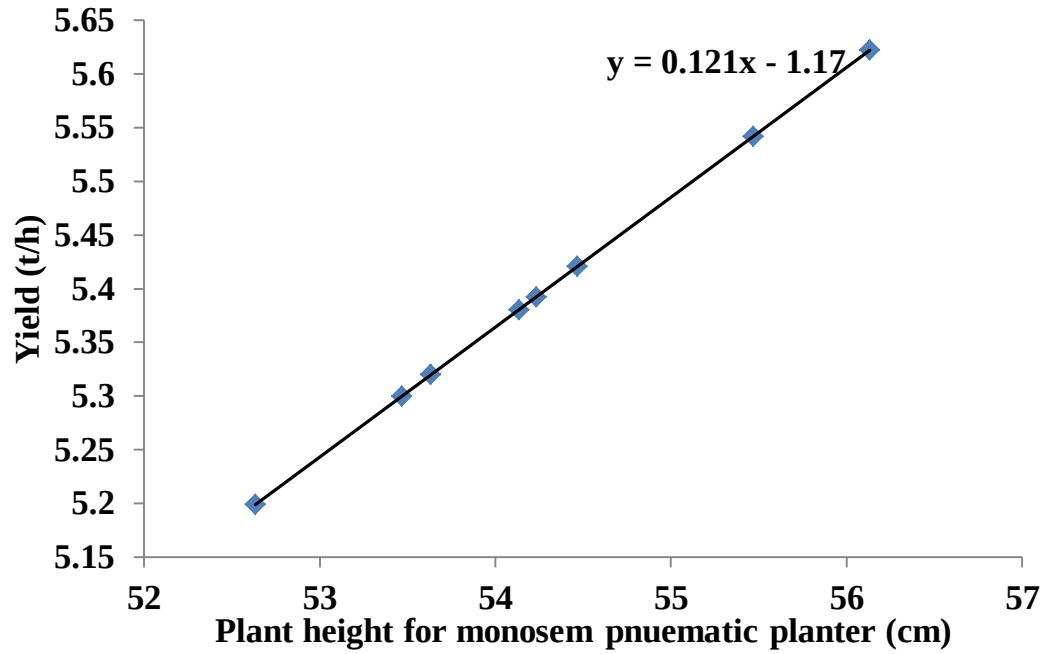


Fig 1b: Linear Relationship between Yield and plant height for Monosem planter.

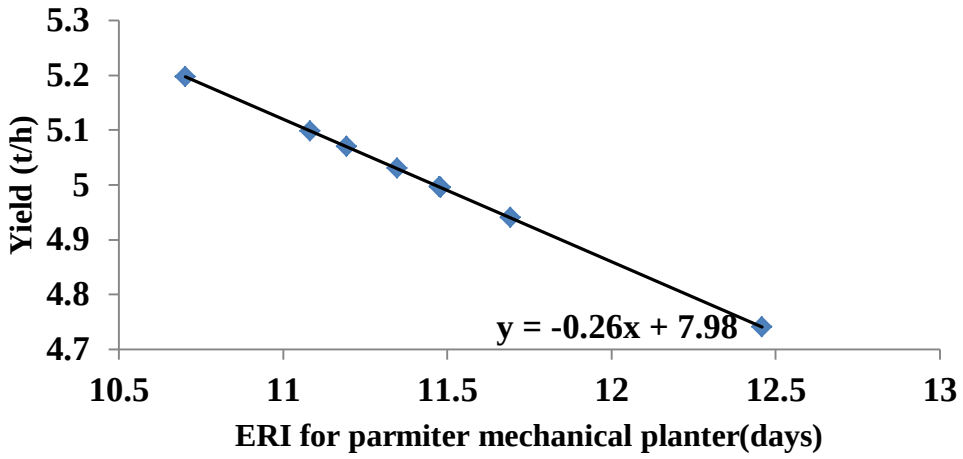


Fig 3a: Linear correlation relationship between yield and ERI for Parmiter Planter

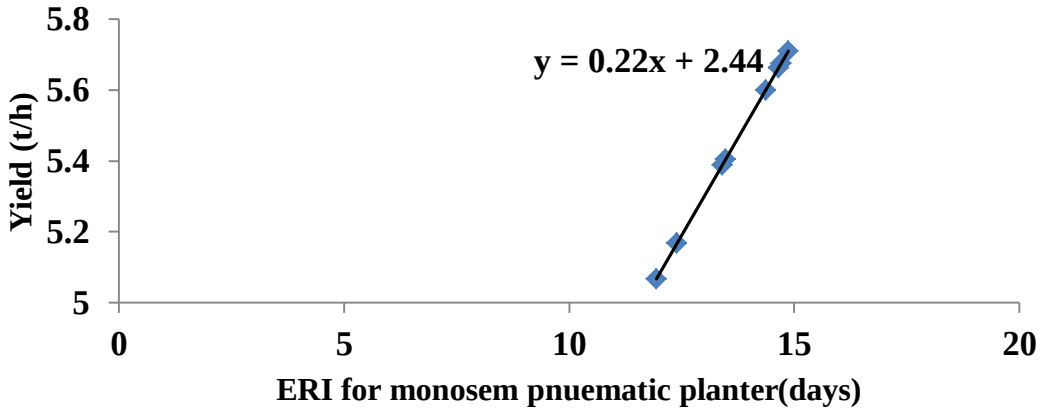


Fig 3b: Linear correlation relationship between yield and ERI for Monosem Planter.

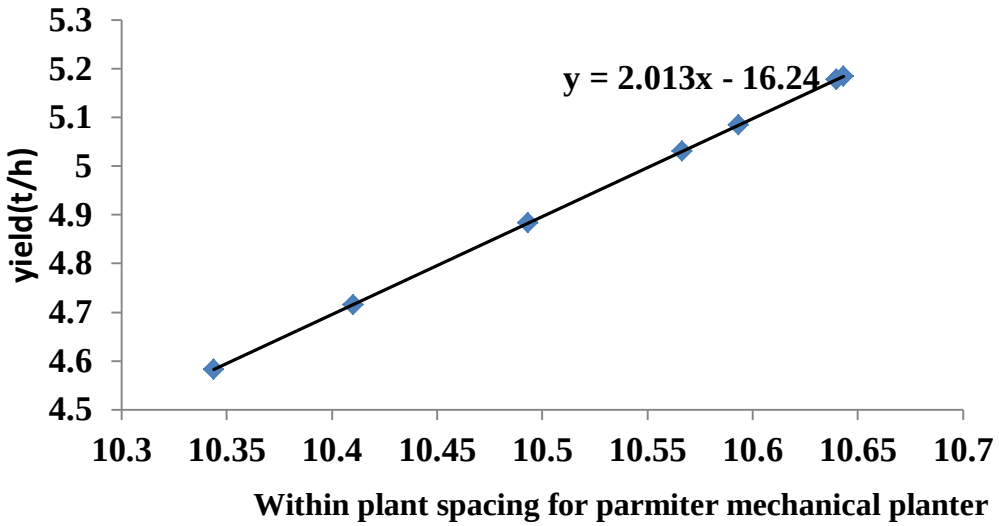


Fig 4a: Linear correlation relationship between yield and spacing for Parmiter Planter

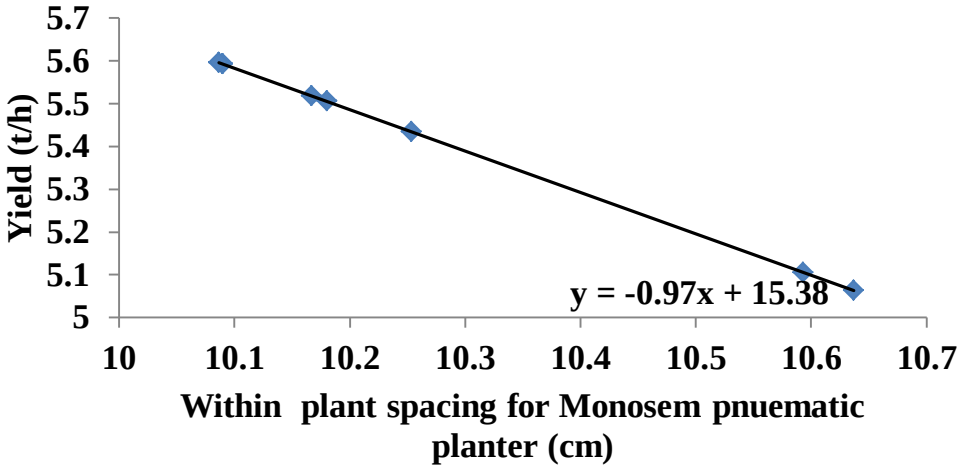


Fig. 4b: Linear correlation relationship between yield and spacing for Monosem Planter.

ESTIMATING TIMELINESS COST FOR PLANTING AND HARVESTING OPERATIONS IN A SEMI – MECHANIZED FARM IN BAUCHI STATE NIGERIA

B.G. Jahun[1] and S.A. Iya[2]

[1]Department of Agricultural Engineering, Abubakar Tafawa Balewa University, Bauchi, Nigeria
[2]Department of Agricultural and Environment Engineering Federal University of Technology, Yola, Nigeria

ABSTRACT

The estimation of timeliness costs of planting and harvesting (done manually) of maize on a semi-mechanized farm within the savanna agro-ecological zone of Nigeria was conducted. Badala farm in Bauchi Local Government Area was used as a case study. In the months of May to October, 2009, the timeliness costs were largely due to field parameters such as probability of working days, effective field capacity, and vagaries of weather which were determined insi-tu at Badala farm. The estimated timeliness cost for planting and harvesting were 5,691.35 Naira/ ha / day and 5,732.65 Naira per ha / day respectively.

1. INTRODUCTION

Timeliness cost is a time – related penalty decreasing the total revenue in crop production. This penalty is associated with risk. It arises when an operation is performed at a non-optimal time or with non-optimal capacity of the equipment thereby affecting the quality or quantity of a crop (Whitney, 1995). Timeliness cost arises in all crop production practices since it is not possible to undertake all crop production operations at the optimal time. Generally, timeliness cost is higher in areas with short-growth season or high precipitation or both (Lund, 1996). Timeliness penalty depends on the performance capacity of the machine used for the field operation. Hence, it is a function of direct machine and labor cost, considered as part of the total cost of owning and operating machinery. Increased performance capacity is associated with higher direct machine investment and decreased labour costs (de Toro and Hansson, 2003). A penalty incurred as a result of non-optimal time of field operations, which increases on a daily basis as the duration is extended. In Nigeria, the optimum time of ploughing, planting and other cultural practices are tied to the beginning of the rains while the length of the rainy season varies from 140 – 200 days in the Northern Guinea Savannah areas of Nigeria. The optimum planting time is different for the Southern to Northern parts of Nigeria (Kassam et al., 1975). A delay in sowing corn within the optimum planting period within the Savannah agro-ecological zones of Nigeria may lead to yield losses of about 80kg /ha/ day (Amoruwa et al., 1987). In view of this, the study is aimed at estimating timeliness cost of critical operations(planting and harvesting) for Maize cultivation within the Savannah agro-ecological zone, Nigeria and Badala farm having fulfilled the criteria set is located at longitude 09^{o}47'E and latitude 10^{o}23'N. The farm has a 140 hectares cultivated during 2009 farming season.

2. METHODOLOGY

Every field operation is best done at the optimum time. If the operation is not done at that optimum time, the quantity and / or quality of crop would be compromised. For example, yield may decrease one percent per day if the operation is not done on the optimum date (de Toro, 2004). This is called timeliness, and can be calculated as a cost resulting from a decrease in

income. The size of the cost depends on factors such as crop value, crop yield, machine operation, weather, and hours available for work per day.
The factors determining timeliness are given in equation (1) proposed by ASAE Standards (2000).

$$T_c = \frac{K.A^2.Y.V}{Z.G.C.(P_{wd})} \quad \text{(1)}$$

Where

T_c = Timeliness cost for the operation ₦/ha/day
k = Timeliness loss coefficient (1 day $^{-1}$)
A = Crop area involved (ha)
Y = Yield (Kg ha^{-1})
Z = Scheduling factors, which is 4 if the operation can balanced evenly about the optimum time and 2 for premature or delayed schedule.
G = Expected time available for field work each day (h).
C = Effective machine capacity (hah^{-1})
P_{wd}= Probability of a work day (decimal)

Management can more or less control machine capacity (machine width, speed, field efficiency) and daily working hours, but the probability or number of work days for field operations are largely outside the farmers influence as these depend on the complex relationship between machinery system, soil and weather (Edwards and Boehlje, 1980). This relationship is usually site-specific with respect to soil, climatic and management factors (Hadas et al., 1988).
For sowing and harvesting, it is possible to start too early as well as too late as reported by Carina and Hansson (2003) for example, it is possible to start harvesting grain before it is fully ripe.

This gives the timeliness cost a different appearance (Nilsson, 1976).

$$S = \sum_{i=l}^{m} \left(\frac{ni}{2} - 1\right) k_i.P_i.l_i.n_i.0.5(₦) \quad \text{(2)}$$

Where
S = timeliness cost ₦/ha
m = is the number of crops grown
n_i = is the average number of days to perform the operation (including days that are not workable on the crop)
k_i = is the average area of crop harvest per day (also including not workable days).
The parameter is calculated by

$$n_i = \frac{A_i}{B.P.C(\text{Days})} \quad \text{(3)}$$

Where:

A_i = total area of the crop
B = the number of work hours per day
P = the workable probability

Different methods can be used to determine timeliness cost. In the model used the timeliness cost was considered to be linearly dependent on the time between the optimal and the actual time for an operation on each area unit. The same method is used by the American Society of Agricultural Engineers, (ASAE) (short and Gitu, 1991).

Effect of Field Machinery Performance in Timeliness Cost Estimation

The main thrust of farm machinery in field operations is to determine the minimum cultivations that are necessary for a successful crop production and to enhance the possibility of increasing yields through good soil tillage practices.

The capacitive performance of an agricultural machine measures the field area covered per unit of time. This capacity performance termed effective field capacity was first evaluated and given in an equation form by Mc Kibben (1930).

The equation was given as:

$$C = \frac{SWe}{10} \quad (4)$$

Where

C = Effective field capacity, ha/h

s = Field Speed, Km/h

w = Machine width, m.

e = Field efficiently, decimal

In this equation, theoretical field capacity is the rate a machine will perform its intended functions if it is operated continuously or uninterrupted at its rated width. Effective field capacity is the average rate a machine will perform its intended function including allowance for loss of time including minor field adjusting, servicing and operator personal times. Field efficiency is the ratio of effective field capacity to theoretical field capacity and it includes the effect of time lost in the field and of failure to utilize the full width of the machine (Gwarzo, 1990).

Time lost during field operations result from many causes. Kepner et al., (1977) reported that turning; idle to travel, and machine adjustment times tend to be proportionate to operating time, while other delays such as stopping to fill seed, interruptions caused by poor field and crop conditions and stopping to unload harvested crops tend to be proportional to area.

3. RESULTS AND DISCUSSION

Timeliness cost resulting from untimely planting and harvesting operations estimated is shown in Table 1 with the highest penalty during harvesting operations which was largely due to harvesting operation conducted manually. Maize yield in the study area was 1.19 ton/ha which is very low, partly due to erratic rainfall after silking and drought spell for 8 consecutive days during the grain filling stage. This confirms the findings of Kowal and Kassam (1974) who indicated that a maize crop might experience water stress if there was no rain for a period of 5 days or more especially when the evapotranspiration rates were 4 – 6 min per day. Planting should be done in time to allow rainfall to continue for six or seven weeks after flowering (silking). This will guaranteed 4 – 5t/ ha of on-farm yield (Fajemisin, 1991). Fatsuma (1989) observed that yield of maize due to delay in planting time gave the highest grain yield of 2.8t/ha from 3 weeks after optimum planting time. Following this was 2.54t/ha from 4 weeks after maize planting treatment. This was contrary with 1.19t/ha for 3 weeks delay in planting and 8 weeks delay in harvesting operations at Badala farms.

REFERENCES

ASAE Standards (200): Agricultural Machinery Management Data, ASAEEP 496.2 DEC. 99. 4^{7th} ed. ASAE St. Joseph, Michigan, USA Pp. 344-349.

Amoruwa, G.M.,Ogunlela, V.B. and Ologunde, O.O. (1987). Agronomic Performance and Nutrient Concentration of Maize (zea mays L.) as Influenced by Nitrogen Fertilization and Plant Density. Journal of Agronomy and Crop Science, 159(4): 226 - 231

Carina, G. and Hansson, (2003: Optimization of Field Machinery for an Arable Farm to Organic Farming Agricultural system 80 (2004) 85-103. Swedish University of Agricultural sciences Uppsala, Sweden.

de Toro, A.A and Hansson, P.A (2003): Analysis of Field Machinery Performance Based on Daily Soil workability Status Using Discrete Event Simulation on Average Workday Probability.

de Toro, A.A. (2004). Assessment of Field Machinery Performance in Variable Weather conditions Using Discrete Event Simulation Unpublished Doctoral Thesis, Swedish university of Agricultural Sciences, Uppsala.

Edwards, W. and Boehlje, M. (1980): Machinery Selection Considering Timeliness Losses Transactions of the ASAE 23(4), 810-815, and 821.

Fajemisin, J.M. (1991). Approaches to increase Production of Early Maturity Maize in Semi-Arid WA.IIIA-SAFGRAD, 01 BP 1495, Ouagadougou Burkina Faso.

Fatsuma, M. (1989): Maize-Pigeon Pen Intercropping Studies: Effect of Date of Planting on Grain and Fodder Yields. Unpublished B.Tech. Agric, Abubakar Tafawa Balewa University, Bauchi.

Gwarzo, M.A.S. (1990): Capacitive Performance Study and Optimization of Power and Machinery on Large Scale Farm. Unpublished PhD Thesis, Department of Agricultural Engineering, Ahmadu Bello University Zaria, Nigeria.

Hadas, A., Larson, W.E. and Allmaras, R.R. (1988) Advances in Modeling: Machine-Soil-Plant Interactions. Soil and Tillage Research 11, 349-372.

Kassam, A.H., Kowal, J.M. and Harrison, M.N. (1975): Maize in West Africa and its Potential in Savanna Area. World Crops, March/April, 1975.

Kepner, R.A., Bainer, R. and Barger, E.L. (1977): Principle of Farm Machinery the AVI Publishing Co. Inc. West Port, Connecticut.

Lund, M. (1996): Mechanization in Organic Farming. A Review of Problems and Suggestions on Solutions.

Mc Kibben, E.G. (1930): Some fundamental Factors for Determining the Effective Capacity of Field Machine. Agric. Engineering, 11:55-57.

Nilsson, B (1976). The Planning of Farm Machinery Systems, Problems, Models and Applications. Report No.38. Department of Agricultural Engineering, Swedish University of Agricultural Sciences, Uppsala, Sweden.

Short, C. and Gitu, K.W. (1991): Timeliness Cost for Machinery Selection. Can. J. Agric. Economy 39, 457-462.

Whitney, R.D. (1995): Choosing and Using Farm Machines. Land Technology Ltd 3rd Edition, Edinburg Scotland, U.K.

Table 1: Estimated Timeliness Cost During Planting and Harvesting Operations

	Planting	Harvesting
Timeliness Factor (K_t), decimal	0.0781	0.0176
Crop area involved (ha)	140	140
Yield, Y ($kgha^{-1}$)	1100	1100
Value of the crop, V (Nkg^{-1})	70	70
Expected time available for field work each day (hr)	8	10
Effective field capacity (ha/hr)	11.83	1.19 (Gwarzo, 1990)
Probability of a work day, P_{wd} (decimal)	0.233	0.258
Scheduling factor	2	2
Timeliness cost for the operations, T_c (N/ha/day)	5,691.35	5,732.65

SORGHUM CROP GRAIN YIELD MODEL IN A SEMI-ARID REGION OF NIGERIA

Dauda, A.[1], Ohu, J. O.[1]and Usman, B.[2]

[1]Department of Agricultural and Environmental Resources Engineering
Faculty of Engineering, University of Maiduguri, Maiduguri, Borno State, Nigeria.
dauda_abdu@yahoo.com
[2]Department of civil and Water Resources, Engineering, University of Maiduguri, Maiduguri. Nigeria.

ABSTRACT

A mathematical model to predict grain yield of sorghum from soil properties, plant height, tillage methods and tractor traffic was developed. The model is semi mechanistic based on some assumptions. The assumptions were derived from empirical results. It is a linear function with some non linear variables. It is therefore reasonable to take the model as non linear function that was solved using non linear regression procedure using SPSS Version 16 computer program. This procedure minimized the error due to deviations and therefore rendered the solution more accurate as could be seen from the improved R^2. Predicted versus observed sorghum grain yield (Kg/ha) for ploughing plus harrowing treatment at all the tractor traffic passes gave the best correlation coefficient(0.96). The model was validated by comparing the predicted grain yields by the model with the actual obtained grain yields from the experiments.

1. INTRODUCTION

During the last half a century, a number of simulation models describing the complex dynamics of the soil and crop were first developed (Loomis and Williams, 1963; de Wit, 1965; Fedes, et al., 1988;Bouman *et al*., 1996). In the 1970s, the complexity of these models increased, giving comprehensive models requiring large quantities of input and output data (Sinclair and Seligman, 1996; Berger *et al*., 1997; Mathews *et al*., 2000). Such models were developed for research in soil and crop studies especially on soil compaction, tillage, crop growth and yield (Hughes, 1995). Some of these models are discussed below;

A mathematical model is a scientific formula with defined limit of application. The principle of mathematical model is that it represents the characteristics of the real system, which are important. It represents generality in solving problems, provides a simplification of complex situation, uses well established techniques of analysis and provides numerical information.

Such models use a set of mathematical equations which may represent well established basic scientific laws (numerical, empirical, analytical, etc), or experimental relationship established for the purpose of the design, possibility on physical or analogue models (Woolhiser and Brakensiek, 1982).

The power of such models is that they can explore a wide range of combinations of design parameters and most importantly lend themselves to optimization and prediction procedures. This type of model can be further subdivided into empirical and theoretical models.

Empirical models are based on observation or experiment and not derived from theory. They involve collection and plotting of data. While empirical models have predictive capacity they have no scientific theories. The empirical model establishes a statistical correspondence between input and output and includes a number of successful approaches such as unit hydrograph, extreme frequency and regression analysis.

Theoretical models provide statement of process (by some type of mathematical formula based on the process) which links the parameters of interest. They are based on complex physical theory and they simplify the physical system. Theoretical models offer both predictive as well as explanations inherent in the proposed processes, which can be examined through corroboration and refutation. They are also able to mathematically explain each of the separate effects. Such models can only be operated through computers because there are many variables and mathematical computations. Theoretical and empirical conditions are mostly interconnected and that most Agricultural and agro-industrial process models include both theoretical and empirical components.

Soil compaction due to tractor traffic is a complex process with many interacting factors. Several models of varying degree of sophistication have been developed to understand this phenomenon. The empirical analytical soil compaction model [SOCOMO] was developed by Van den Akker (2004) to predict soil stress under wheel loads. This model has been successfully used to predict soil stress under tractor wheels. Although simple, requiring only a minimal input, it is user friendly. This model is based on the assumption that soils can be compacted to a finite maximum bulk density (ρ_{max}), unlike earlier models which were based on logarithmic functions (Bailey and Van den Berg, 1967; Larson *et al*., 1980; Gupta and Larson, 1982; Bailey *et al*., 1986).

Analytical models usually contain fewer parameters and are often easier to use than FEM (finite element models) models.

Augusto (2003) developed a fuzzy logic soil compaction model which aimed to predict the change in bulk density, total porosity and penetration resistance due to compaction from wheel traffic and to classify soil compaction level. However, he concluded that the model performance was not satisfactory.

Crop growth simulation models (CGSM) are mathematical, computer based representations of crop growth and interaction with the environment. However, there are some that are not computer based. These models are generally based on the dynamic simulation of crop growth by numerical integration of constituent properties with the aid of computers (Sinclair and Seligman, 1996; Graves *et al*., 2002). Many crop growth models have been developed for use. Some of these models are empirical (Penning de Vries *et al*., 1989), deterministic (Berge *et al*., 1997; Peiris and Thattil, 1998) and stochastic (Mathews *et al*., 2000). Like other models, crop growth models have their limitations. These limitations include their large input data requirements and difficulties in the representation of complex situations numerically (Passioura, 1996; Borrough, 1989). Despite these difficulties, there is evidence that crop growth simulation models can play important roles in scientific research and decision support (Mathews et al, 2000). PARCH model (Bradley and Crout, 1993) simulated the growth and development of sorghum (*Sorghum bicolor* (L) Moench, millet (*Panicummiliaceum* L.), and to a lesser extent, maize (*Zea mays* L.) in semi-arid environments, giving researchers the possibility to observe and experiment with crops from tropical areas (Graves *et al*., 2002). Predicting arable resources capture in hostile environment PARCH model is an ordinary differential equations type of model. The model consists of 4 main sub-models: 1) Crop model, 2) Soil water Balance, 3) Soil nitrogen 4) Soil phosphorus model.

The model uses a daily time step for the simulation of crop growth. The model had been calibrated for four cultivars; of sorghum CSH-6, CSH-8, M-35-1, and DK using data from 17 experiments. Overall, there is a good agreement between the model and observation, with the model accounting for more than 80% of the observed variation in crop yield. The objective of this

study was to formulate a model for predicting sorghum yield planted in a sandy loam soil from soil properties tractor traffic, tillage methods and plant parameters.

2. MATERIALS AND METHODS

2.1. Experimental Site

The experiment was conducted at The University of Maiduguri Agricultural Engineering Teaching and Research Farm, Maiduguri (Latitude 11^0 54' N, Longitude 13^0 E, altitude 354 m above mean sea level). It is located within the Sahel Savannah zone. The rainy period is between June and September with a mean annual rainfall of about 500mm. There is high temperature during most of the year with an annual mean of about 28^0C. During the months of April to May, the temperature could be as high as 45^0C. However, during the harmattan period, the mean monthly temperature could be as low as 22^0C (Muni, 2002). The soil of the research farm had earlier been classified as Typic Upstisanment (Rayar, 1984) with aeolian sand formation and weakly aggregated. The soil has a sandy loam texture and made up of 6% silt, 17% clay and 77% sand (Ohu *et al*. 1989)

2.2. Methodology

An Excel computer package was used to generate the predicted sorghum grain yields. The model was validated by using non –linear regression procedure in SPSS version 16 for Windows. This procedure minimizes the error inherent in the data using iterative steps. It usually requires that initial values of coefficients be provided. The initial values of the coefficients in equation 30 were determined using multiple regression procedure.

The coefficients of terms in equation 30 as obtained using the non-linear regression procedure for the various types of tillage methods are presented in Appendix 14.

The values of the yield predicted by the model and those obtained by the experiment are presented in Appendix 15. This Table showed that the model was capable of adequately predicting the observed data.

3. RESULTS AND DISCUSSION

3.1. Model Development.

This model development was based on the following assumptions:

1. Yield increases linearly with increase in soil moisture content within the context of rainfall in the recorded experimental area
2. Yield increases linearly with increase in air permeability as measured throughout the period of experiment
3. Yield increases linearly with increase in plant height
4. Yield increases with increase in penetration resistance up to a point and then starts decreasing
5. Yield increases with increase in bulk density up to a point and then starts decreasing
6. Yield increases with increase in number of tractor passes up to a point and then starts decreasing
7. The tillage operations, ploughing, harrowing and ploughing plus harrowing are qualitative measurements

From the foregoing,

$$Y = f(\Theta, \mu, p_h, P_r, \gamma_d, T_p, 0, P, H, PH) \quad (1)$$

Where:

Y = grain yield (kg/ha)
Θ = moisture content (%)
μ = air permeability (μm^2)
p_h = plant height (cm)
γ_d = bulk density (Kg/m^3)
P_r = penetration resistance (MPa)
T_p = number of tractor passes
0 = zero tillage
P = ploughing
H = harrowing
PH = ploughing plus harrowing

Sorting out the qualitative parameters, equation (1) becomes

$$Y = f(\Theta, \mu, p_h, P_r, \gamma_d, T_p) \quad (2)$$

Assuming that y is a linear function of Θ,

$$y_\Theta = f(\Theta) \quad (3)$$

$$y_\Theta = C_1 + a_1\Theta \quad (4)$$

assuming that y is a linear function of μ,

$$y_\mu = f(\mu) \quad (5)$$

$$y_\mu = C_2 + a_2\mu \quad (6)$$

assuming that y is a linear function of P_h ,

$$y_{Ph} = f(P_h) \quad (7)$$

$$y_{Ph} = C_3 + a_3P_h \quad (8)$$

Taking the 4th assumption, this is a 2nd order polynomial relationship between y and Pr,

$$y_{Pr} = f(P_r) \quad (9)$$

$$y_{Pr} = C_4 + b_1P_r - a_4P_r^2 \quad (10)$$

$$y_{Pr} = C_4 + b_1(b_2 - a_4P_r^2) \quad (11)$$

Taking the 5th assumption, this is a 2nd order polynomial relationship between y and γ_d,

$$y_{\gamma d} = f(\gamma_d) \quad (12)$$

$y_{\gamma d} = C_5 + b_3\gamma_d - a_5\gamma_d^2$ (13)

$y_{\gamma d} = C_5 + b_3(b_3 - a_5\gamma_d^2)$ (14)

Taking the 6th assumption, this is a 2nd order polynomial relationship between y and Tp,

$y_{Tp} = f(T_p)$ (15)

$y_{Tp} = C_6 + b_5T_p - a_6T_p$ (16)

$y_{Tp} = C_6 + b_5(b_6 - a_6T_p^2)$ (17)

Equation (1) now becomes

$Y = \Sigma_{i=1}^{n} f(\Theta, \mu, p_h, P_r, \gamma_d, T_p)$ (18)

Solving equation (18) and simplifying, yields:

$Y = C_1 + a_1\Theta + C_2 + a_2\mu + C_3 + a_3p_h, + C_4 + b_1(b_2 - a_4P_r^2) + C_5 + b_3(b_4 - a_5\gamma_d^2) + C_6 + b_5(b_6 - a_6T_p^2)$ (19)

Let $C_1 + C_2 + C_3 + C_4 + C_5 + C_6 = C'$ (20)

$Y = C' + a_1\Theta + a_2\mu + a_3p_h, + b_1b_2 - b_1a_4P_r^2 + b_3b_4 - b_3a_5\gamma_d^2 + b_5b_6 - b_5a_6T_p^2$ (21)

Assuming that the yield responses to the interaction between Θ and γ_d, is in the form of Θ/γ_d,

$y_{\Theta 1\gamma d} = a_x\Theta/\gamma_d = y_{\Theta 1\gamma d} = a_7\Theta/\gamma_d$ (22)

Equation (21) becomes,

$Y = C' + a_1\Theta + a_2\mu + a_3p_h, + b_1b_2 - b_1a_4P_r^2 + b_3b_4 - b_3a_5\gamma_d^2 + b_5b_6 - b_5a_6T_p^2 + a_7\Theta/\gamma_d$ (23)

Let $b_1b_2 + b_3b_4 + b_5b_6 = C''$ (24)

$Y = C' + C'' + a_1\Theta - a_2\mu + a_3p_h - b_1a_4P_r^2 - b_3a_5\gamma_d^2 - b_5a_6T_p^2 + a_7\Theta/\gamma_d$ (25)

If the like terms are brought up together,

$Y = C' + C'' + (a_1\Theta + a_7\Theta/\gamma_d) - b_2a_5\gamma_d^2 - a_2\mu - b_1a_4P_r^2 - b_3a_6T_p^2$ (26)

The expression $\Theta(a_1 + a_7/\gamma_d)$ could be taken as $\Theta(a_1 + a'\ln\gamma_d)$ (27)

Let $C' + C'' = C$

$Y = C + \Theta(a_1 + a'\ln\gamma_d) - b_2a_5\gamma_d^2 - a_2\mu - a_4P_r^2 - b_3a_6T_p^2$ (28)

a_1 and a' are assumed to be related to Θ in such a way that

$\Theta(a_1 + a'\ln\gamma_d) = Z\ln(\Theta/\gamma$ (29)

and since b_2a_5 and b_3a_6 are constants ,

Let $b_2a_5 = k$ and $b_3a_6 = m$ and $a_2 = a$, $a_3 = d$, $a_4 = b$

Equation (28) then becomes,

$Y = C + q\Theta + Z\ln(\Theta/\gamma_d) - k\gamma_d + a\mu - bP_r^2 - xT_p^2 + dP_h$ (30)

Where, C is a constant, ln is natural logarithm and q, Z, k, a, b,x and d are term coefficients.

Equation (30) $Y = C + q\Theta + Z \ln(\Theta/\gamma d) - k\gamma d + a\mu - bPr2 - xTp2 + dP_h$ was then tested on the data obtained at zero tillage ,plowing ,harrowing and ploughing plus harrowing using non – linear procedure to obtain the constants and the coefficients :c ,q ,Z ,k ,a , x and d.

The coefficients of terms in equation 30 as obtained using the non-linear regression procedure for the various types of tillage methods are presented in Appendix 1. The values of the yield predicted by the model and those obtained by the experiment are presented in Appendix 2. This Table showed that the model was capable of adequately predicting the observed data.

3.2. Model Validation

The model was validated by plotting the predicted against the observed yield. Validation of a model shows increase in confidence of the model in relation to solving a particular problem. Model validation involves comparing the observed values with predicted values. The model is said to be validated if the predicted values are in good agreement with the observed data.

Predicted sorghum grain yields were obtained using the developed model.

Figures 1 to 4 show the comparisons between the predicted and observed sorghum grain yields. A good linear relationship were obtained between predicted and observed sorghum grain yields with most of the data points either fit or are closely distributed. In the figures 1 to 4, the data points are uniformly scattered above a straight line having high coefficients of determination. This implies that the relationship between the observed and predicted values of yield did not exhibit a tendency towards a clear tendency and that the model tracked well the observed data. However, the model could be said to yield its best performance in predicting sorghum yield on soil that was subjected to ploughing plus harrowing.

4. CONCLUSION.

The equation $Y = C + q\Theta + Z \ln(\Theta/\gamma d) - k\gamma_d + a\mu - bP_r^2 - xT_p^2 + dP_h$

was formulated to predict the yield of sorghum , and the predicted grain yields correlated well with observed data. Predicted versus observed sorghum grain yield (Kg/ha) for ploughing plus harrowing treatment at all the tractor traffic passes gave the best correlation coefficient(0.96).The model can be used to predict the yield of sorghum in the semi arid region. Generally, the optimum sorghum growth and yield was obtained with PH combined with 10T tractor passes.

REFERENCES

Assouline, S. 2002. Modelling soil compaction under uniaxial compression. Soil Science.1.66:1784-1787.

Augusto, G. 2003. Fuzz modeling of soil compaction due to agriculturalmachine traffic. EIIA conference, Debrecen, Hungary.Pp.97-102.

Bailey. A.C and Vanden Berg, G.E. 1967. Yielding by compaction and shear in unsaturated soils. Trans ASAE 11: 307-317.

Bailey, A.C. Johnson, C.E and Schafer, R.E 1986. A model for agricultural soil compaction. Journal of Agricultural Engineering Research. 33:257-262.

Bradley, R.G and Crout, N.M.J. 1993. The PARCH model for predicting Arable Resource Capture in Hostile environment. Sulton Bonnington, U.K, University of Nottingham.

Burrough, P.A. 1989. Matching special data bases and quantitative models in land resources assessment. Soil use and management 5:3-8.

Bowman,B.A,,Van Keulen,M.H., and Rabinge,R. 1996. The School of de Wit crop growth simulation models: A pedigree and historical overview. Agricultural Systems, 52:171-198.

De Wit,C.T., 1965. Photosynthesis of leaf canoples. Pudoc, Waganingen, the Netherlands.
Fedes, R.A. Kabat, P; Van Bakel P.J.T. 1988.Modeling soil water dynamics in the unsaturated zone - state of the art. Journal of Hydrology. 100(l-3):69-ll 1.
Graves, A.R., Hess, T. Mathews, R.B; Stephens, W and Middleton, T. 2002. Crop simulation models as tools in computer laboratory and classroom based education. Journal of Natural Research. Life Science Education. 31:48-54.
Gupta, S.C and Larson, W.E. 1982 Modeling soil mechanical behaviour during tillage. In Van Doren et al (ed) predicting tillage effects on soil physical properties and processes. ASA spec. publ. 44 pp.151-178.
Hughes, K.A 1995. A ten year maize/ rotation under three tillage systems. Plant population, root distribution and forage yield. Soil and Tillage Research ,22:145-157.
Larson, W.E; Gupta, S.C and Useche, R.A. 1980. Compaction of agricultural soils from eight soils order. Soil Science Society of America Proceedings. 44:450-457.
Loomis, R.S. and Williams, W.A. 1963. Maximum crop productivity: An estimate. Crop Science, 3: 67-72.
Mathews, R.B; Stephens, W; Hess, T; Mason, T. and Grover, A.R. 2000.Applications of crop/soil simulation models in developing countries. pp 82. Cranfield University at Silsoe.Silsoe, U.K.
Passouira, J.B. 1996. Simulation of models:Science, education or engineering?Agronomy Journal. 88:690-694.
Peiris, T.S.G and Thattil, R.O. 1998. The study of climate effects on the nut yield of coconut using parsimonious models.Experimental Agriculture. 34:189-206.
Penning de vries F.W.T, Jansen, D.M; Bergers H.F.M and Bakama, A. 1989.Simulation of ecophysiological processes of growth in several annual crops. Simulation monographs. Pudoc/IRRI, Wageningen, the Netherlands.physical properties of some soils.Iowa State College Journal of Purseglove, J.W. 1988.Tropical crops.Monocotyledons 5th edition.Eongman Scientific and Technical Group Ltd. England.
Sinclair, T.R and Seligman, N.G. 1996. Crop modeling; from Infancy to maturity J.Agr. 88:698-703.
Van den Akker, J.J.H. 2004. Development,verification and the use of the soil compaction model (SOCOMO). Proceedings of the concerted action. The Netherlands, Wageningen ,D.L.O Winand centre,pp321-336.
Woolhiser, D. A. and Brakensiek, D.L. 1982. Hydrologic modeling of small watersheds (HaanC.T.,Johnson, H.P. and Brakesiek,D.L. editors). American Society of Agricultural Engineers.pp 3-15.Michigan,USA.

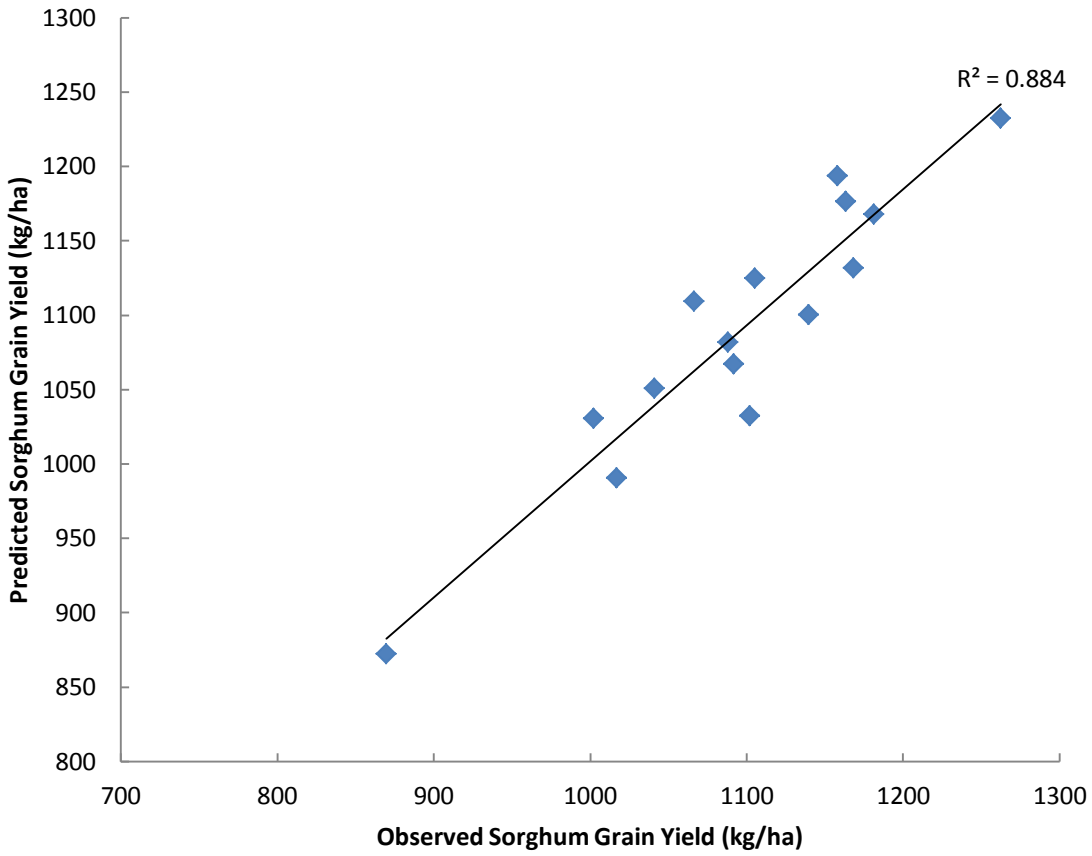


Figure 1: Predicted versus observed sorghum grain yield (Kg/ha) for zero tillage treatment at all the traffic passes.

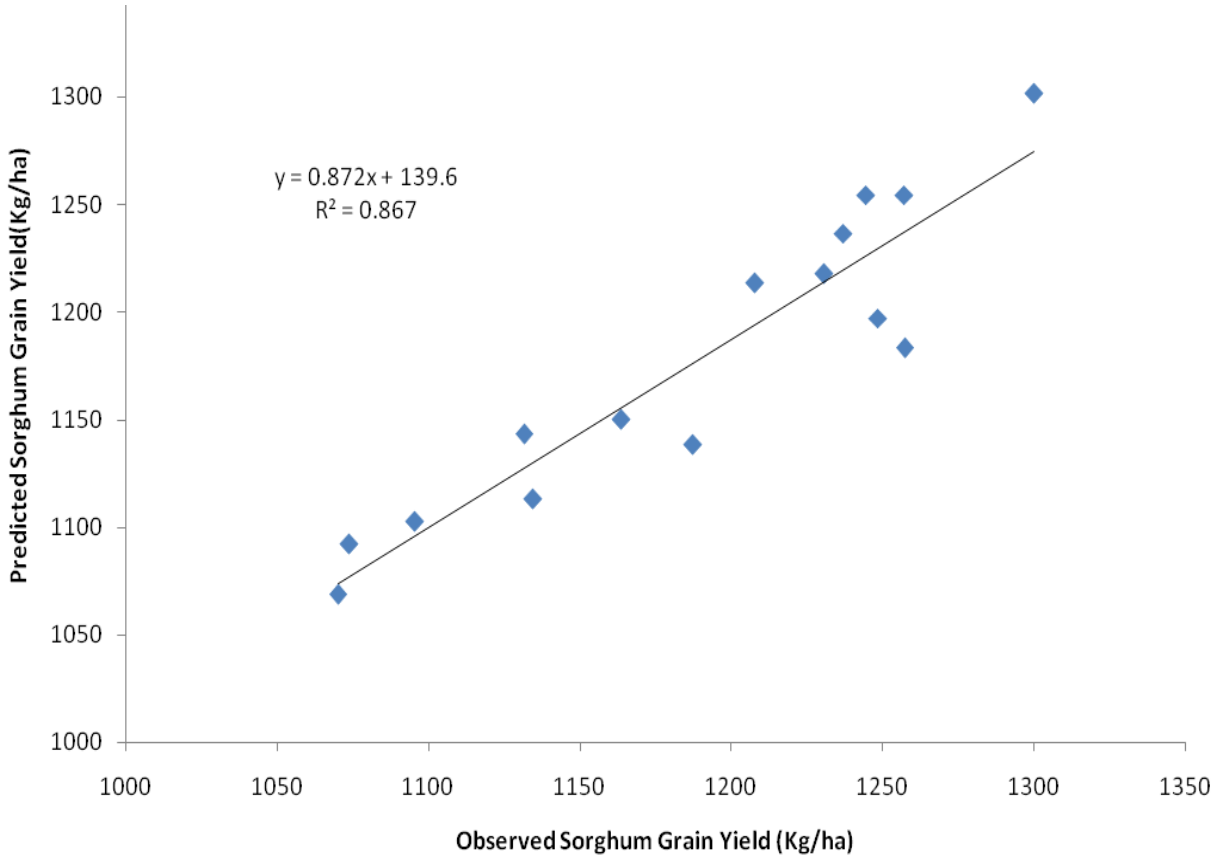


Figure 2: Predicted versus Observed Sorghum Grain Yields (Kg/ha) for ploughing treatment at all the traffic passes.

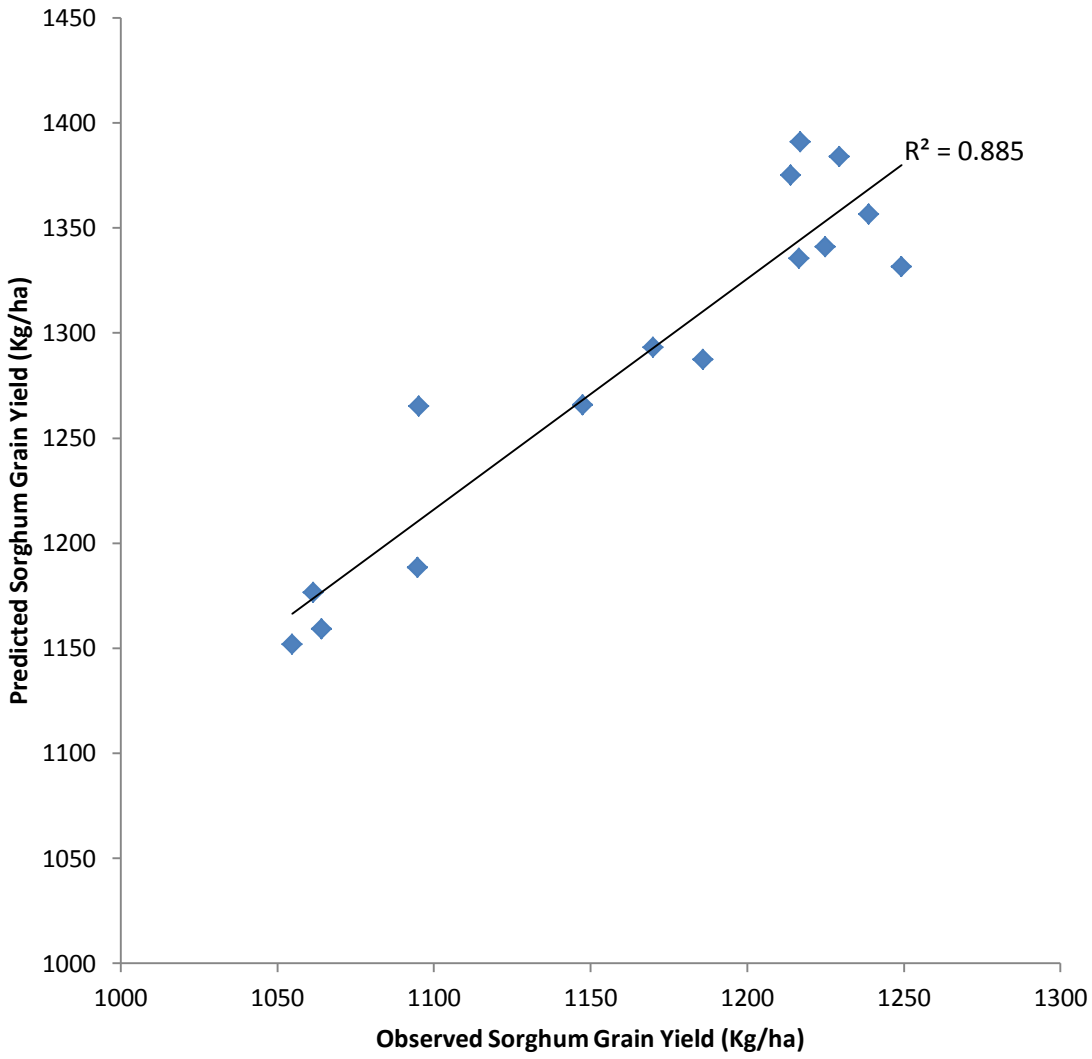


Figure 3: Predicted versus observed sorghum grain yield (Kg/ha) for harrowing treatment at all the traffic passes.

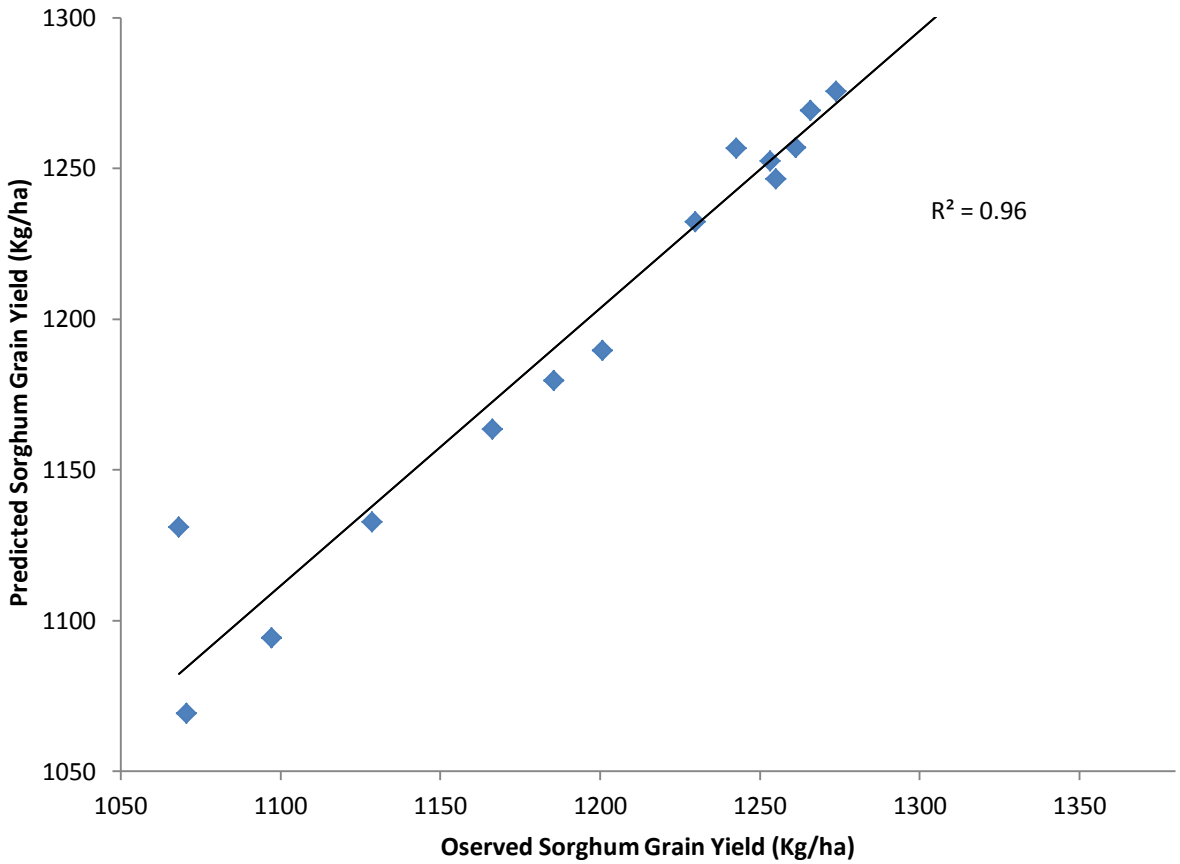


Figure 4: Predicted versus observed sorghum grain yield (Kg/ha) for ploughing plus harrowing treatment at all the tractor traffic passes.

Appendix 1: Coefficients of terms in equation 30 for sorghum grain yield on different tillage methods.

	Zero Tillage	**Ploughing**	**Harrowing**	**Ploughing plus Harrowing**
C	2.38E+03	2.57E+03	1.51E+03	165.48
Q	-1.56E+03	1.44	429.39	1.36E+03
Z	468.02	724.8	415.7	-0.15
K	-61.03	304.14	-390.49	210.84
A	-0.02	3.52	1.14	5.05
B	-110.47	189.55	3.89	-10.81
X	1.019	-1.39	0.32	0.07
D	-128.48	62.89	-27.47	62.2

Appendix 2: The observed (O) and predicted (P) values of sorghum grain yield (Kg/ha) for different tillage methods (a) zero tillage,(b) ploughing , (c) harrowing and (d) ploughing plus harrowing.

(a)		(b)		(c)		(d)	
O	P	O	P	O	P	O	P
1017.1	990.5	1095.5	1102.5	1061.4	1176.5	1097.2	1094.3
1105.5	1124.9	1237	1236.7	1147.6	1265.8	1242.6	1256.6
1181.6	1167.8	1230.8	1217.9	1238.8	1356.5	1273.8	1275.5
1066.6	1109.1	1131.6	1143.2	1094.8	1188.3	1128.7	1132.6
1163.4	1176.2	1248.6	1197.1	1169.9	1293	1255.1	1246.5
1262.5	1232.3	1300	1301.6	1249.2	1331.4	1353.9	1354.6
1088	1081.6	1134.6	1113.2	1095.3	1265	1166.4	1163.5
1168.5	1131.5	1257.2	1254.5	1229.5	1383.7	1261.2	1256.8
1157.9	1193.6	1257.4	1183.4	1217	1390.8	1253.2	1252.5
1041.1	1050.9	1074	1092.3	1064.2	1159.2	1070.7	1069.3
1139.5	1100.1	1187.5	1138.2	1216.5	1335.3	1200.8	1189.5
1092	1067	1244.6	1254.4	1213.9	1375	1229.8	1232.2
869.6	872	1070.2	1068.6	1054.8	1151.7	1068.2	1130.9
1002.1	1030.5	1163.8	1149.9	1185.9	1287.2	1185.6	1179.5

SECTION II

SOIL AND WATER ENGINEERING

OPPORTUNITIES FOR EFFECTIVE MANAGEMENT OF IRRIGATION WATER AT FIELD LEVEL

H. E. Igbadun[1*] and I. E. Ahaneku[2]

[1]Department of Agricultural Engineering, Ahmadu Bello University, P.M.B. 1044, Zaria, Kaduna State, Nigeria
[2]Department of Agricultural and Bioresource Engineering, Federal University of Technology, Minna, Niger State, Nigeria
* Corresponding author Email address: igbadun20@yahoo.com

ABSTRACT

Irrigated agriculture has long been identified as one of the keys to achieving the much desired increase in food production to meet the food requirement of the growing population of Nigeria. As the water resources of many river basins dwindle and competition for water by non-agricultural sectors of the basins increases, the conventional methods of irrigation practiced by farmers in many irrigation schemes with the objective of maximizing yield per area cultivated can no longer be accommodated if irrigated agriculture is to be sustained. There is a need for a paradigm shift from the prevailing methods of using water at field level to those which have the potentials of minimizing water utilization while optimizing crop returns. This paper reviews some irrigation systems and techniques of water application aimed at effective water management that can be explored to provide a platform for sustainability of irrigation in Nigeria. It also highlights research gaps that need to be filled in order to maximize the benefits from these irrigation water management practices.

Keywords: Irrigated agriculture, water management, water utilization, convention irrigation methods

1. Introduction

Irrigated agriculture has proved to be one of the keys to achieving the much desired increase in global food production to meet the food requirement of the world's ever increasing population. According to a report from the Food and Agriculture Organization (FAO, 2003), irrigated agriculture contributes about 40% of the food supply from only 20% of the world's farmland under irrigation. The report further states that the highest crop yield obtained from irrigation is more than double the highest yield from rain-fed agriculture, and that even low input irrigation is more productive than high input rain-fed farming.

Over three and half decade ago, Nigeria adopted irrigated agriculture has one of the strategies for increasing food production for her teaming and fast growing population. Government both at the Federal and State level have consistently invested in irrigated agriculture since then. Ejieji and Amodu (2008) citing Nwa (2003) listed 187 small-scale and 117 medium and large-scale government-owned (or sponsored) irrigation schemes existing in Nigeria, with irrigable potentials of about 0.433 million ha. There are also numerous private-owned and traditional irrigation schemes scattered around the country putting the irrigable land area at about 0.975 million ha and a potential of about 3.14 million ha (Lawal et al, 2007). Crops cultivated under irrigation have multiplied from rice, sugarcane, wheat and tomato in the 1980s and 1990s to include green maize,

leafy vegetables, carrot, different species of melon, cabbage, cucumbers, lettuce, onions, groundnut, eggplants, etc. However, the system of irrigation in most of the irrigation schemes is still surface. Farmers still practice wild or controlled flooding in check basins, furrows and border strips. In these methods of irrigation, the interest of the irrigator is to give crop enough water so as to achieve maximum production per unit area of land. In many cases, the amount of water applied per irrigation is seldom known because it is not always measured. Farmers irrigates as long as they see water, and in some cases until the fields are inundated.

In some of the organized irrigation schemes, a rotational water delivery programme is put in place which allows farmers access to irrigation water every five (5) days or once a week. This method automatically imposes a fixed irrigation interval in the system. It has its advantage as every farmer know when he is to irrigate and can plan his irrigation and other activities around his days of irrigation. Such an arrangement has worked well in reducing conflict over water, and it is also easier for extension workers to explain to farmers on when to irrigate. However, the method does not take care of the problem of field flooding which has always been a major source to wastage of water. Some farmers have the habit of breaking open the canals and leave for their homes, with the expectation that their fields will get enough water on the day water is rotated towards their canals. Field flooding leads to water logging, high rise in water table depth and consequent build-up of salinity. The methods of irrigation have largely been responsible to the low water productivity recorded for most irrigated crop in Nigeria.

The array of problems associated with the conventional methods of irrigation and its objective calls for a paradigm shift in the way irrigation is practiced in Nigeria. The objectives of irrigation should begin to change from maximizing yield per unit area to sustainability of irrigation as a whole. That entails adoption of effective irrigation water management strategies that could help to maximizing yield per water applied, minimizing energy requirement, and maximizing net returns for irrigation. This objective of this paper is to raise awareness of some methods of water application and agronomic technique which can lead to the realization of this goal. The practices highlighted, though not new, are yet to be fully explored by Nigerian irrigators and researchers; hence this paper. Some research gaps that need to be filled in order to maximize the benefits of these practices are also highlighted.

1. Field Techniques for Effective Water Management

2.1 Alternate furrow and skip-furrow irrigation methods

The conventional method of furrow irrigation in most Nigerian irrigation schemes is to make water run in every furrow from the upstream to the tail end. Some irrigators block the tail end of the furrows so that the tail water is pounded while some others allow the tail water to flow out of the field as runoff. This method of irrigation is prone to over-irrigation, waste of water, high energy and labour cost. Alternate furrow irrigation is a method whereby water is applied to every other furrow rather than to every furrow. The furrows that were not irrigated in the previous irrigation will now be the ones to be irrigated (see Fig.1). Where the alternate furrows are not irrigated at all throughout the crop growing season (though they are planted to crops), this method of irrigation is regarded as skip-furrow. Other variants of alternate furrow method include skipping furrows at selected crop growth stages, or use alternate furrow method at the early to vegetative growth stages and every-furrow method at flowering to maturity method. These methods of irrigation is expected to reduce the amount of water used per irrigation, time spent to irrigate the field, labour cost and energy if the water is being lifted using a pump. Although, the

crop may be subjected to some level of moisture stress leading to reduction in crop yield, but the cost-benefit ratio with respect to water, labour, time, and energy saved may be high. This practice has been widely used in the USA (Box et al. 1963, Fishbach and Mulliner, 1974; Tsegaye et al., 1993; Mitchell et al., 1995) to improve irrigation efficiency with good result in crops like potato, corn, sorghum, and cotton. Large water saving (up to 50 %) without lost in yield has been achieved with substantial reduction in the labour required to carry out the irrigation (Stone and Wofziger, 1993; Mitchell et al., 1995). Even where yield reduction was recorded under this method of irrigation (e.g. Samadi and Sepaskah, 1984; Crabtree et al., 1985) significant saving in the volume of water used were achieved, depending on the price of the water, resulting in an improved crop profitability. These methods of irrigation are yet to be explored in Nigerian irrigation schemes. Research is required to evaluate the irrigation efficiencies (water application, storage and distribution), crop-water productivity, economic returns and soil water balance of these methods of irrigation for different soils and crops for different locations. Furthermore, stream sizes (flow rate) for different soil types, hydraulic characteristics, when to cut-back the stream flow to avoid excess water impounded at the tail end, and optimum water application depths so as to minimize deep percolation vis-a-vis different furrow lengths are knowledge gaps that need to be filled under this practice.

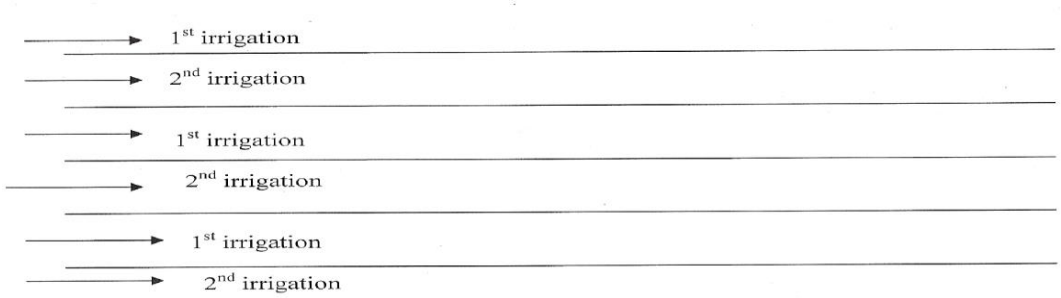


Fig.2: Alternate furrow irrigation

2.2 Deficit Irrigation Scheduling

Deficit irrigation scheduling is the practice of irrigating crops below the full water requirement. Deficit irrigation scheduling does lead to yield reduction, but researches have shown that with carefully planned it is possible to increase the amount of crop produce per unit of water (Kirda, 2002; Kadayifci et al. 2005). So much has been reported on deficit irrigation scheduling in the developed and Asian countries, but very few works have been documented for Sub-Saharan Africa countries (Pandey et al., 2000; Igbadun et al., 2006, 2008, Bekele and Tilahum, 2007; Ramalan et al., 2010), and for Nigeria in particular (Igbadun et al, 2012). This suggests that a lot more research work on deficit irrigation in needed in the region.

There are different ways to use deficit irrigation to manage irrigation water. One method is to reduce the depth of irrigation water applied, refilling only a part of the soil reserve capacity in the root zone. This concept of irrigation scheduling is referred to as evapotranspiration (ET) deficit irrigation (Stegman et al., 1980). In this method, the expected root zone is filled to field capacity at planting period; a low soil water deficit is maintained in the early season; frequent irrigation is observed in the peak ET period to maintain high water potential in the 0-30 cm root zone depth; full irrigation requirement is given in the flowering and fruiting period so that these irrigation

plus the earlier stored water in the lower root zone can supply the late season ET requirement. Another deficit irrigation scheduling concept is to reduce the frequency of irrigation at crop growth stages that are known to less sensitive to moisture stress, and give the full water requirement at growth stages that are more critical to moisture stress. This can be done by skipping one or two regular irrigation event at those growth stages that are less sensitive to moisture stress, and maintain the regular irrigation event during the growth stage that is more sensitive to moisture stress. This concept is referred to as critical growth stage irrigation (GSI) or control deficit irrigation (CID). The scheduling method which entails skipping irrigation events at selected growth stage may be easier to implement by farmers compared to the method of reducing water application depth.

The skipping method has the advantage of reduced number for the season, thus saving water and cost of irrigation per season. Igbadun et al. (2005) reported an experiment in which weekly irrigation event were skipped at different growth stages of a maize crop in Tanzania. They found that the irrigation scheduling protocol which entails skipping regular irrigation event once after every other irrigation at vegetative crop growth stage gave the highest productivity of water. The crop yield under that scheduling method was not significantly different from the treatment which received regular irrigation at 7-day irrigation interval throughout the crop growing season. But the scheduling strategy saved 1100m^3/ha of water and its economic advantage was about $12.3/ha when compared with the treatment which was irrigated on weekly basis. Research gaps for such study in Nigeria include establishing the deficit tolerance limit for different crops and soil types, and for different methods of administering deficit irrigation for given locations.

2.3 Deficit Irrigation with Mulching

Deficit irrigation with mulching is another potential method of minimizing water utilization at field level to save water. Mulching involves the use of organic or inorganic materials to cover the cropped soil surface, which can reduce surface evaporation, conserve soil moisture, modify soil temperature, and improve aeration. Crop residues and grasses are typical organic materials commonly used for mulching, while synthetic materials (e.g. polyethylene sheet of different thickness and colours) are typical inorganic materials use for mulching. Research evidence had shown that soil surface evaporation contributes largely to the total evapotranspiration in the cropped field (Ahmad et al., 2007). Not until the crop attains full vegetative cover, evaporation dominates the moisture depleted from the plant root zone. Water loss through evaporation, though may have assisted in influencing the micro-climate in which the crop developed, is not beneficially used by the crop in yield production. Reducing the rate of evaporation by mulching the soil surface makes more water readily available in the soil. The crop is therefore able to balance its water use with atmospheric water demand, thus maintaining plant leaves turgidity, which in turn enhances radiation use efficiency and biomass yield production. Mulching with plant residues and/or synthetic materials is a well-established technique for increasing the profitability of many horticultural crops (Duranti and Cuocolo, 1989; Gimenez et al., 2002). Synthetic mulches can reduce weed problems and certain insect pests and also stimulate higher crop yields by more efficient utilization of soil nutrients (Rhu et al., 1990; Kashi et al., 2004).

Field experimental studies carried out by Igbadun et al (2012) on deficit irrigation scheduling with rice straw, black and white polyethylene as mulch materials for onion crop (Table 1) showed that bulb yield ranged from 7.6 to 19.5 t/ha when the crop was irrigated with water application depths varying from 25 % (I_{25}) to 100 % (I_{100}) of weekly reference evapotranspiration. With

seasonal water application depths varying from 225 to 495 mm, crop water productivities of the deficit irrigated treatments (I_{25}, I_{50} and I_{75}) were found to be about 9 to 32 % higher than the fully irrigated (I_{100}) treatment. The crop water productivities of the mulched treatments were also found to be about 4 to 27 % higher than the no- mulch treatment. Research gaps in the practice of deficit irrigation with mulch include how much water to apply at the different growth stages of the crops and the frequency of irrigation that will minimize yield losses while minimizing the cost of irrigation (water, energy and labour). This information must be related to the soil type, climate and crop.

Table 1: Bulb yield, seasonal water applied and crop water productivity of onion under deficit irrigation with mulching for two cropping season in Samaru, Zaria

Treatment	**2008/09 irrigation season**			**2009/10 irrigation season**		
	Bulb Yield t/ha	Seasonal Water applied (mm)	Crop water productivity (Kg/m^3)	Bulb Yield t/ha	Seasonal Water applied (mm)	Crop water productivity (Kg/m^3)
I_{25}	10.83	225.0	4.81	7.63	230.0	3.43
I_{50}	13.80	310.0	4.45	12.78	315.0	4.05
I_{75}	17.53	395.0	4.44	14.35	405.0	3.54
I_{100}	19.45	480.0	4.04	15.13	495.0	3.06
M_{BPM}*	16.00	352.5	4.64	14.18	361.3	4.03
M_{WPM}	15.15	352.5	4.36	11.60	361.3	3.30
M_{RSM}	16.33	352.5	4.70	12.70	361.3	3.58
M_{NM}	14.13	352.5	4.05	11.40	361.3	3.16

* M_{BPM} = mulched with black polyethylene; M_{WPM} = mulched with white transparent polyethylene; M_{RSM} = mulched with rice straw; M_{NM} = No mulch.

3.1 Irrigation techniques for effective water management in smallholding farms

3.1 Pit (holes) irrigation method

This is a system of irrigation in which pits (holes) are made beside each plant stand (or between two stands in the same row) (Fig.2) and only the holes are filled with water during irrigation other than the entire field. The depth of the pits may be about 30 to 80 cm, depending on the rooting depth of the crop. This method of irrigation was referred to as middle-depth stereoscopic irrigation as it delivers water to the deep root zone (Sawaf, 1980; Bainbridge and Virginia, 1990) in comparison with the traditional surface irrigation. It does not only decrease sufficiently soil evaporation during irrigation, it also makes rhizosphere soil absorb water rapidly. According to Xihuan (2002), this method of irrigation has the characteristics of saving irrigation, help to conserve moisture in the soil, and can store local rainfall runoff; thus preventing water and soil losses, and improving on the water hydrological cycle locality. This system of irrigation is

suitable for orchard and arboretum in mountain and rolling area (Xihuan, 2002). Bainbridge (2006) reported a study carried out in the Sonoran desert of California in which survival was tolerated with a total of only 10 litres of water delivered to each tree over the first three years through water storage pit irrigation system compared to total failure of surface irrigated trees given the same amount of water within four months. In this study perforated pipes installed vertically beside the trees were used to deliver water to the rhizosphere. Water saving pit irrigation system can also be practiced in household gardens using watering cans and buckets. Although it may be labour intensive, its potentials to save water and increase crop water productivity could be very high. Aspects of research in this system of irrigation include field engineering of the water storage pits (depth, diameter and number per field plot), facilities for fixing the storage pits, agronomic and water productivity advantages.

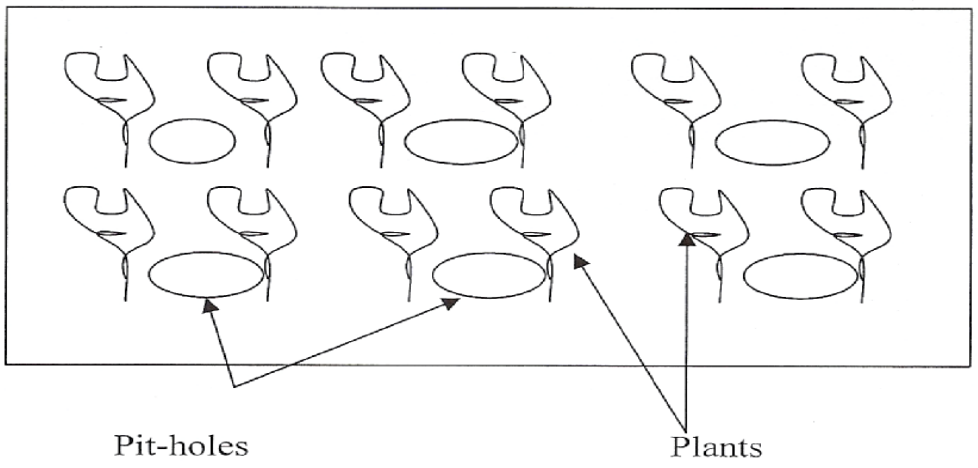


Fig.5: Pit irrigation method

3.2 Pitcher or clay pot irrigation system

In this method of irrigation, clay pot (which is a porous medium) is placed in a hole between the plants (Fig.3). Water is poured into the pot, and as the plant take up water from the soil around the pot, the matric potential in the soil causes water to move through the body of the clay pot into the surround soil. The size and shape of the pots to be used depends on the type of crop. Some pots could hold 5-20 litres of water. Small round pots can be used for growing vegetables, while larger and deeper pots can be used in orchards (Hune, 2005).Pitcher irrigation system can be practiced where water is either scarce or expensive, fields are difficult to level such as uneven terrain, or water is saline and cannot be normally used in surface methods of irrigation. One of the advantages of using pitchers for irrigation is the result of their water saving capacity. To compare pitcher irrigation to flood or sprinkler irrigation one must correct for the fact that the scales are radically different. Pitcher irrigation is used on small-scale, while flood and sprinkler systems are for more extensive irrigation. Taking this into account, pitcher irrigation is still more efficient. Pitcher irrigation uses water more efficiently than other systems since it delivers water directly to plant root zones, instead of to broader areas of the field. With pitcher irrigation, deep percolation

losses are negligible since water is released from smaller areas, and the rate of water loss can be controlled site to site by the amount of water put in each pitcher. Water requirements in a pitcher irrigated field can be even less than those of a drip irrigated system (of the same scale) due to the very low hydraulic conductivity of the pitchers, as well as reduced evaporation losses. Abu-Zregy (2008) reported a tomato yield of 45t/ha for pitcher irrigation compared to 40 t/ha for surface irrigation. The crop water use under pitcher irrigation was 195 mm/season compared to 650 mm/season for surface irrigation. Aspects of research in this method of water application include field engineering of pitchers (materials, thickness, diameter and geometry of pipesvis-a-vis seepage rate and wetting pattern for different soil and climatic condition), agronomy (crop types, plant spacing, and frequency of irrigation), etc.

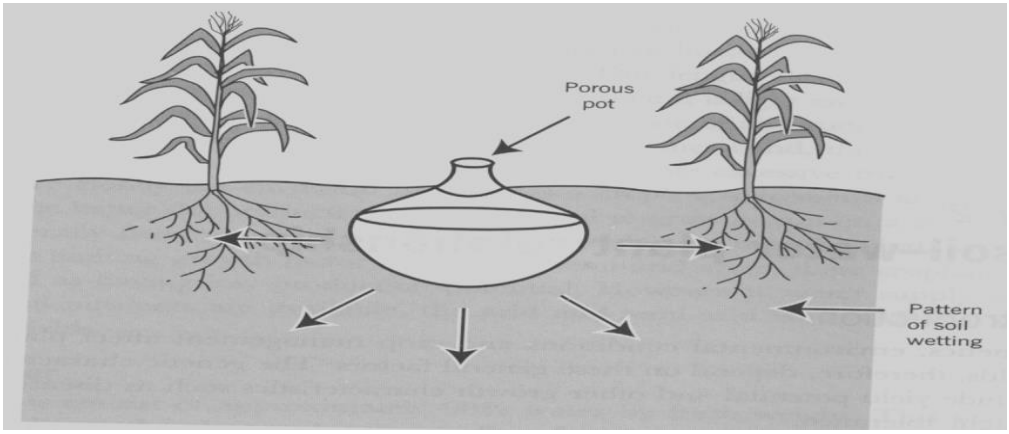


Fig. 3: Pitcher or clay pot irrigation (source: Hune, 2005)

3.3 Subsurface irrigation using clay pipes

The clay pipes irrigation is also based on principle of clay pot/pitcher irrigation. Clay pipes of 250 to 500 mm length with an inside diameter of 75mm can be joined to form a long tube (Plate1). The pipes are placed along the entire length of the beds by laying them end-to-end in a levelled trench. At one end, a right angle fitting is attached and an upright section of pipe installed. The trench is then backfilled with soil to a depth of 100 to 200 mm, depending upon the soil type (Fig.4). Water is poured into the porous pipe through the upright pipe. Water seeps into the root zones through the joints between the individual pipes, or through the pipe walls if unglazed clay pipes are used. Water seeps from pipe through the pores and forms a wetted zone. Varying the frequency of filling, the size of the pipe and the spacing between pipes affects the watering process. Barnabas (2011) investigated the hydraulic properties of locally made clay pipes (1.5 m long, 10 cm diameter and 1.2cm thickness) made from 100 % clay, 95 % clay mixed with 5% sawdust, and 85% clay mixed with 15 % fine sand and 5% sawdust in Zaria, and reported seepage rate of 1.69×10^{-6}, 2.53×10^{-6}, and 3.94×10^{-6}, m^3/s, for the respective clay pipes (Plate 1). The seepage rates from the pipes were able to adequately irrigate Amaranthus spp. (vegetable). Research gaps in the use of this system are similar to those of pitcher irrigation.



Plate 1: Clay pipes made by Barnabas (2011)

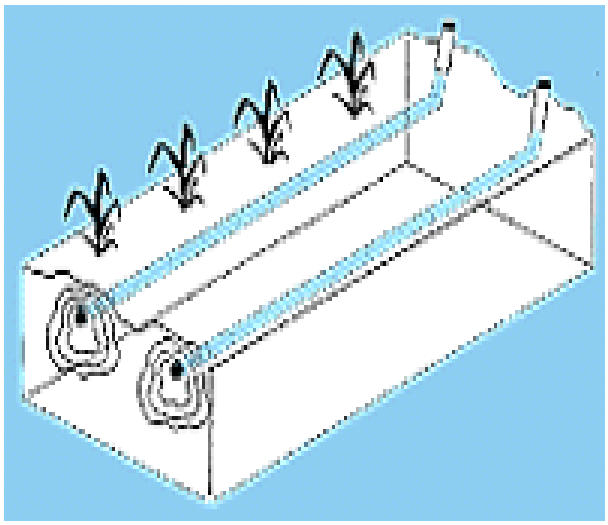
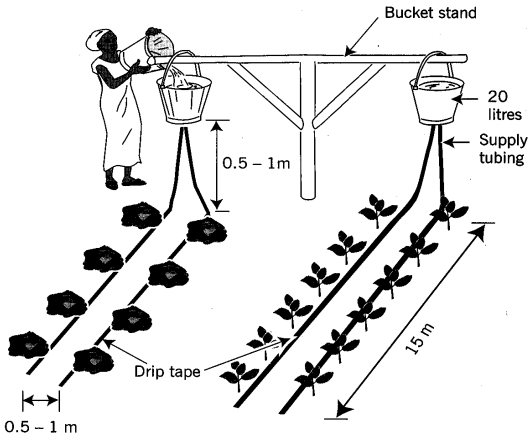
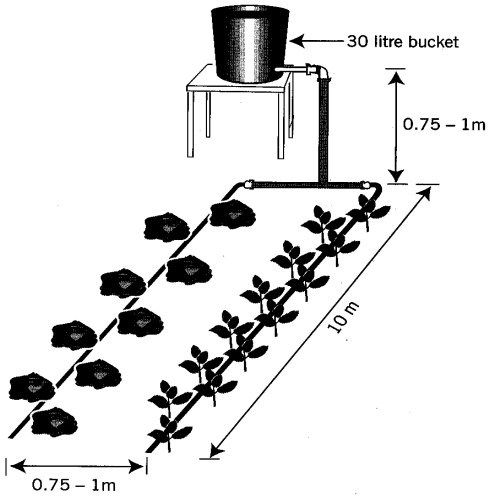


Fig.4: Pattern of wetting front of clay pipes

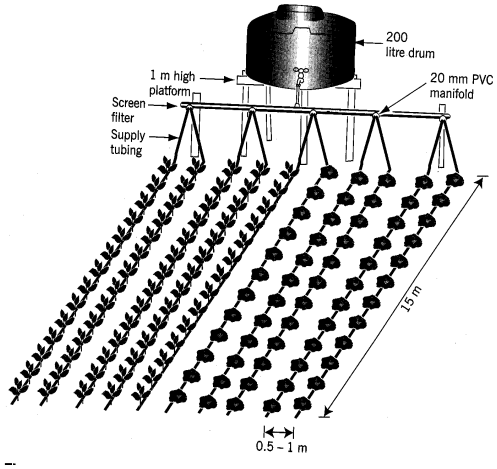
3.4 Small holder drip irrigation kits

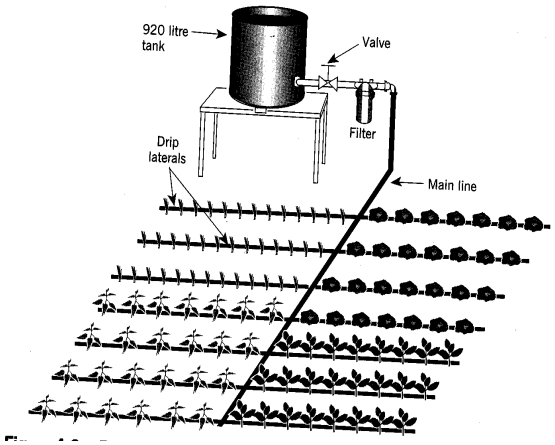
These include the bucket kit (Figs.5 a & b) and drum kit (Figs.5c&d) systems. These are low cost dripirrigation (LCDI) kits which are suited for small fields and maintain the water saving advantages of conventional drip irrigation system, presenting opportunity to substantially increase the economic and food security of low income farmers. The International Development Enterprise, a non- profit organisation have introduced LCDI to many third-world countries with a high degree of success in terms acceptability and use. LCDI are used by farmers in India, Kenya, Zambia, Malawi, Niger, Nepal, etc. In a comparative study of LCDI, conventional drip irrigation system and hand watering for cauliflower under different water regime in Nepal, von Westrapet al (2004) reported that regardless of irrigation regime, the cumulative yields of cauliflower were higher in LCDI than the other two methods of irrigation. They concluded that the LCDI was a more viable option to increase food production in water scare, small scale farming both in terms of economic and labour benefits. In Nigeria, LCDI has been introduced to farmers in some North-western States of Kastina, Zamfara, and Sokoto, however there are yet documentation on the extend of use and associated problems. Aspect of research urgently needed include comparative study of LCDI with conventional surface, drip, and hand watering methods of irrigation; field engineering of LCDI with respect to, pressure head, emitter flow rates, irrigation scheduling for different crops and soil types, agronomic practices, etc





(a) (b)Fig.5a& b:Bucket Kit small household drip system





(c) (d)

Fig.5c & d: Drum Kit small household drip system

4. CONCLUSION

The way forward to sustainability of irrigated agriculture in Nigeria is to observe paradigm shift from the current farmers' practices of conventional wild or control flooding irrigation methods to some of the practices reviewed in this paper. In order to adapt some of these irrigation water management techniques to our localities, field testing and evaluation is necessary in order to establish appropriate methodology that are suitable to our soils, water sources and availability, and will be easily acceptable to farmers before they are extended out.

REFERENCES

Abu-Zregy, M. 2008.Pitcher irrigation. Paper presented (power point) at the 2nd MEDA Water Regional Event on Local Water Management, Marrakeh, 28-30, April, 2008

Ahmad, M.D., Turral, H., Masih, I., Giordano, M., Masood, Z. 2007. Water saving technologies: Myths and realities revealed in Pakistan's rice-wheat system. Colombo, Sri-Lanka: International Water Management Institute (IWMI) research Paper 108, 44p.

Bainbridge, D.A. 2006. Beyond deep irrigation –hyper efficient irrigation systems. Proceedings American Society of Agricultural and Biological Engineering Annual International Meeting, Portland, Oregon, ASABE#062073, St. Joseph, Michigan, 10p.

Bainbridge, D.A. and R.A. Virginia. 1990. Restoration in the Sonoran Desrt. Restoration and Management Note 8(1):3-14.

Barnabas, J. 2011. Development of porous clay pipes for sub-surface irrigation. Unpublished Undergraduate Final Year Project in the Department of Agricultural engineering, Ahmadu Bello University, Zaria.

Bekele, S., Tilahum, K., 2007.Regulated deficit irrigation scheduling of onion in a semi arid region of Ethiopia. Agric. Water. Management 89: 148-152.

Box, J.E., Sletten, W.H., Kyle, J.H., and Pope, A. (1963). Effects of soil moisture, temperature, andfertility on yield and quality of irrigated potatoes in the Southern Plains. Agron. J. 55: 492 - 494.

Crabtree, R.J., Yassin, A.A., Kargougou, I., McNew, R.W. (1985). Effect of alternate furrowirrigation: water conservation on the yields of two soybean cultivars. Agric. Water. Management .10(3): 253 - 264.

Duranti, A., Cuocolo, L. 1989. Chemical weed control and mulching in onion (Allium cepa. L.) and garlic (Allium sativum. L.). Adv. Hort. Sci. 37:338-342.

Ejieji, C.J., Fasasi, M.B., 2003. Development of a soil water sensor using gypsum block and a multi-meter. Journal of Agricultural Research and Development 2:89-92.

FAO, 2003.Improving Irrigation Technology. Food and Agricultural Organization Spotlight Magazine AG 21, May 2003.

Fishbach, P.E. and Mulliner, H.R. (1974).Every-other furrow irrigation of corn. Trans. ASAE.17(3): 426 - 428.

Gimenez, C., Otto, R.F., Castilla, N. 2002. Productivity of leaf and non vegetable crops under direct cover. Science Horticulture 94:1-11.

Hune, N. 2005.Training Manual on Rainwater Harvesting and Utilization Techniques. Ministry of Agriculture, Addis Abba, Ethiopia. 77pp.

Igbadun, H.E, Ramalan, A.A. and Oiganji, E. 2012. Effects of regulated irrigation deficit and mulch on yield, water use and crop water productivity of onion in Samaru, Nigeria. Agric. Water Manage. Vol.109:162-169. http://dx.doi.org/10.1016/j.agwat.2012.03.006

Igbadun, H.E., B.A. Salim, A.K.P.R. Tarimo and H.F. Mahoo. 2008. Effects of deficit irrigation scheduling on yields and soil water balance of irrigated maize. Irrigation Science 27:11-23. DOI 10.1007/s00271-008-0117-0. Springer publication (available online at:http://www.dx.doi.org/) Publisher: Springer, U.S.A.

Igbadun, H.E., H.FMahoo, A.K.P.R. Tarimo and B.A. Salim. 2006. Crop water productivity of an irrigated maize crop in Mkoji sub-catchment of the Great Ruaha River Basin, Tanzania. Agricultural Water Management 85:141-150. (http://www.sciencedirect.com).

Igbadun, H.E., H.F. Mahoo, A.K.P.R. Tarimoand B.A. Salim. 2005. Productivity of water and economic benefit associated with deficit irrigation scheduling in maize. Proceedings of the East Africa Integrated River Basin Management Conference. pp. 18-28.

Kadayifci, A., Tuylu, G.T., Ucar, Y., Cakmak, B., 2005. Crop water use of Onion (Allium cepa. L.) in Turkey. Agric. Water. Management, 72: 59-68.

Kashi, A., Hosseinzadeh, S., Babalar, M., Lessani, H., 2004.Effect of black polyethylene mulch and calcium nitrate application on growth and yield of watermelon (Citrulluslanatus. L). J. Sci. Tech. Nat. Res. 7:1-10.

Kirda, C., 2002. Deficit irrigation scheduling based on plant growth stages showing water stress tolerance. In: Deficit Irrigation Practice. Water Reports 22.FAO, Rome, pp. 1-3.

Lawal, A.O., Yiljep, Y.D., Othman, M.K., Akpoko, J.G. and Murtala, G.B. 2007.The level of adoption and use of irrigation and drainage technologies in Nigeria. Proceedings of the 13th National and Drainage Seminar (Abubakar, I.U and Othman, M.K, ed): 173-184

Mitchell, A.R., Shock, C.C., and Perry, G.M. (1995).Alternating-furrow irrigation to minimise nitrate leaching to ground water.Conference Proc. 'Clean Water-Clean Environment-21stCentury', March 1995, Kansas City, Missouri, ASAE.

Pandey, R.K., J.W. Maranville and Admou, A. (2000).Deficit irrigation and nitrogen effects on maize in Sahelian environment I. Grain yield and yield components. Agric. Water Manage., 46: 1-13.

Ramalan, A.A., Nega, H., Oyebode, M.A. 2010. Effect of deficit irrigation and mulch on water use and yield of drip irrigated onions. WIT Transaction on Ecology and the Environment, Vol. 134:39-50

Rhu, A.K., Mushi, A.A.A., Khan, M.A.H. 1990. Effect of different mulches on the growth of potato (Solanumtuberosum. L.). Bangladesh J. Bot. 19:41-46.

Samadi, A., and Sepaskah, A.R. (1984). Effects of alternate furrow irrigation on yield and water useefficiency of dry beans. Iran Agric. Research. 3(2): 95- 115.

Sawaf, H.M. 1980. Attempts to improve the supplementary irrigation systems in orchards in some arid zones according to the root distribution pattern of fruit trees. In Rainfed Agriculture in the Near East and North Africa.252-259, Rome, Italy, FAO.

Stegman, E.C., Musick, J.T. and Stewart, J.I. (1980).Irrigation water management. In: Design and Operation of Farm Irrigation Systems (Edited by Jensen, M.E). ASAE Monograph No 3. pp. 763-816.

Stone, J.F. and Nofziger, D.L. (1993).Water use and yields of cotton grown under wide-spaced furrow irrigation. Agric. Water Management 24(1): 27- 38.

Tsegaye, T., Stone, J.F., and Reeves, H.E. (1993). Water use characteristics of wide spaced furrow irrigation. Soil Sci. Soc. Am. J. 57: 240 - 245

Von Westrap, S., Chieng, S. and Schreier, H. 2004.A comparison between low-cost drip irrigation, conventional drip irrigation and land watering in Nepal. Agricultural Water Management 64:143-160

Xihuan, S. 2002. Effect of water storage pit irrigation on soil and water conservation. 12thISCO conference held in Beijing, 2002. www.tucson.ars.ag.gov/isco/isco12/

A REVIEW ON THE USE OF DRIP IRRIGATION IN NIGERIA

Oiganji Ezekiel[1]*, O.E Nwafor[1] and A. Ahmed[2]

[1]Forestry Research Institute of Nigeria, Federal college of forestry, Jos; Dept of Crop Production Technology
[2]Dept.of Agricultural Technology, Abubakar Tatari Ali Polytechnic Bauchi
* Corresponding Author: ezeganji@yahoo.com +2348061279887

ABSTRACT

Adoption of drip irrigation technology is a pre-requisite for sustainable Agriculture in the scope of future agricultural productivity in Nigeria, Agricultural productivity has to increase drastically to meet the UN"s millennium development goals of eradicating extreme poverty and hunger. Water availability in the root zone limits crop production in large parts of Nigeria. In view of this it has become necessary for the adoption of drip irrigation technology in different part of the country, a review is presented of attempt made by different scientist in Nigeria with the use of drip irrigation technology to promote better understanding, facilitates a more rational analysis of the use of drip irrigation technology.

Keywords: drip, irrigation, low-cost, emitter, lateral, pipe

1.0 Introduction

Increasing the efficiency of water use by crops has continue to be a topic of concern because of growing competition for fresh water and the need to face the food crisis in developing countries, the key factors causing increase in water demand over the last century are population growth, industrial development and expansion of irrigated agriculture among others. If the same water consumption pattern continues, two out of three people on earth will live under water-stressed conditions by the year 2025 (Karlberg and penning de Vries,2004).

The trend in recent years has been towards conversion of surface to drip irrigation, which is considered to be a more efficient delivery system. Scheduling water application is very critical to make the most efficient use of drip irrigation system, as excessive irrigation reduces yield, while inadequate irrigation causes water stress and reduces production (Phene and Sanders, 1976; Nakayama and Bucks, 1986).

For a long time drip-irrigation was perceived as technique too sophisticated and costly to be operated and managed by small-scale farmers; conventional technologies have a high capital cost, high tech in nature making it complicated to install and maintain; so continuous search for an alternative low cost drip technology which will be applicable for developing countries is of paramount importance. Now low cost drip irrigation system is emerging as one of the popular alternative of traditional drip irrigation system in many developing and under developed countries (Chitsiko and Mudima, 2002).

Small-scale farmers dominate the agricultural sector of most developing countries and are now perceived as key players in increasing global food production and achieving food security

(Frausto,2000).The focus on upgrading smallholder agriculture is essential, since small farmers make up around half of the food insecure population of the world (FAO,2004)

Micro-irrigation technologies, commonlyinuseinwater scarceareasof developedcountries,constituteone suchinterventionwiththeabilitytousewater more efficientlyinirrigatedagriculture. Thesetechnologies can improve productivity; raise incomes throughcrop yieldsand outputs; and enhance foodsecurity of households. Numerous studies have established the gains from micro-irrigation adoption and several governmentandnon-governmentorganizationsareengaged inactively promoting thetechnologies(Narayanamoorthy 1996).

Gravity drip irrigation system is one of the fastest expanding technologies in modern irrigated agriculture with great potential for achieving high effectiveness of water-use. It allows judicious use of water and fertilizer during irrigation of a wide range of crops (Mofoke *et al*;2006). Drip irrigation technique for control of irrigation water is presently being employed at India, Israel, Jordan, Spain, Australia, Mexico, Kenya, Zimbabwe, Malawi. In Nigeria drip system is been introduced to farmers in some North-Western States of Kastina, Zamfara and Sokoto (Oyebode *et al*., 2011). Water is conducted under low pressure to a network of closely spaced outlet which discharges water slowly at virtually zero pressure with the purpose of supplying water to limited soil volume in which active root uptake can take place (Victor *et al;* 2008).

Drip irrigation systems have greatly improved over the last twenty years with a lot of effort from the western irrigation suppliers who were responding to the demands of commercial agricultural enterprises. Initially it failed to meet the widespread need for cheaper, divisible irrigation systems for poor farmers on small plots. The development of a reliable low cost drip system that fits the needs of smallholder farmers in developing countries has received a lot of attention over the last decade (Polak, *et al*., 1997; Postel, *et al*., 2001 ; Mehari *et al*., 2003; Manaktala 2005; Maisiri,Senzanje et al. 2005).

2. History of Drip Irrigation

The creation of inexpensive, weather resistant plastic after World War II paved the way for drip irrigation; through a network of perforated plastic tubing installed on or below the soil surface, drip systems deliver water under low pressure almost directly to the roots of plants through small holes or emitters. Engineer Blass conceived the first idea of drip in Israel in 1930-1940, Blass performed the first trials with a subsurface system in fruit trees in 1959 and in 1962 the first success with surface drip irrigation in vegetables was recorded. Since it commercial acceptance in the mid-1970s, the hardware used in drip irrigation systems has evolved to fit large fields which are expensive and rather sophisticated. Spectrum of drip system are now available like the bucket kits, drum kits, shiftable Drip System and Stationary Micro Tube Systems that meet the following criteria: affordability, rapid payback, divisibility and water efficiency. Water is delivered to the drip points via a set of plastic tubes, generally weathering-resistant opaque polyethylene or PVC. Lateral lines, supplied from a field main, are laid on the surface. They are commonly 10 to 25 mm in diameter and are either perforated or fitted with special emitters. The latter are designed to drip water on to the soil at a controlled rate, ranging from 1 to 10 litres per hour per emitter. The operating water pressure is usually in the range of 0.5 to 2.5 atmospheres. This pressure is dissipated by friction in flow through the narrow passages or orifices of the

emitters, so the water emerges at atmospheric pressure in the form of drops rather than a jet or spray.
Commercial emitters are either *in-line* (spliced into the lateral supply tubes), or *on-line* (plugged on to the tubes through a hole punched into the tubing wall). Commercial emitters are pre-calibrated to discharge at a constant rate of 2, 4 or 8 liters per hour. The discharge rate is always affected by changes in pressure, but less so in the case of pressure-compensated emitters. The frequency and duration of each irrigation period are controlled by means of a manual valve or a programmable automatic valve assembly (Sandra *et al*., 2001).

The low cost drip irrigation sometimes saved about 35% of the water compared to surface irrigation system. With many of the poorest farmers living in water scarce areas it is important to make maximum use of the scarce water supply. Irrigation efficiency could greatly improve by having a tool that makes it easier to supply the right amount of water to the crops at the right place at the right time. Often water is manually pumped into drum kits so the saving in water also reflects a direct saving in labor input.Drip irrigation is a water-saving technology which enables slow and regular application of water directly to the roots of the plants through a network of economically designed plastic pipes and low discharge emitters. It maximizes crop productivity through increase in the crop yield and also the area for cultivation, and protects the environment through conserving soil, water and fertilizer resources, and thus increasing the farmer income. Modernexperimentationwithdripirrigation systemsbeganinEnglandinthe1940s.However, notuntiltheinnovationofpolyethyleneplasticsin the1960sdiddripirrigatingbegintogain momentum.Traditionally,irrigationhadreliedupon abroadcoverageofwatertoanareathatmayor maynotcontainplants.Promotedforwater conservation,dripirrigationdoesjusttheopposite. Itappliessmallamountsofwater(usuallyevery twoorthreedays)totheimmediaterootzoneof plants. Indripirrigation,waterisdeliveredtoindividual plantsatalowpressureanddeliveryrateto specificareasorzonesinthelandscapeor garden.Theslowapplicationpromotesathorough penetrationofthewatertoindividualplantroot zonesandreducespotentialrunoff.Thedepthof waterpenetrationdependsonthelengthoftime thesystemisallowedtooperateandthetextureof thesoil (Maisiri, *et al*., 2005).

Dripemittersapplythewaterdirectlytoplantroot zonesandareveryefficientandwater-conserving bydesign.Whenapplyingwaterdirectlytothesoil, thereisvirtuallynowastefromdrift,evaporationor runoff.Therearemanydesignsofemitters availableonthemarket,andeventhemini-sprinkler,mistersandmini-sprayertypesare efficientinoperation.

3. Advantages of Drip Irrigation Systems

1. Conservewaterbyapplyingmoisture onlywhereitisneeded,andby eliminatingdrift,potentialrunoffand mostevaporation.
2. Arerelativelysimpletodesignand install.
3. Provideamoreconstantlevelof moisturetoplantroots.
4. Arelessexpensivetoinstallthansome othersystems.
5. Areflexibletoexpansionordesign changes.
6. Maybeconcealedtomaintainthe beautyofthelandscape,andtoreduce vandalismandliabilitywheninstalledin publicareas.
7. Requiresmallerwatersources,for example,lessthanhalfofthewater neededforasprinklersystem.

8. Arelow-pressuresystems,which requirelessenergycostsifpumpingis necessary.
9. Reducethechanceofplantdiseaseby keepingfoliagedry.
10. Helpcontrolweedsbynotproviding watertoareaswhereitisn'tneeded.
11. Arecapableofefficientautomated fertilizationwhencombinedwiththe properemitters.
12. Arecapableofefficientautomated fertilizationwhencombinedwiththe properemitters.
13. Arecapableofapplyingmoistureon variedterrainsinavarietyofsoil conditions.
14. Reducesoilerosionandnutrient leaching.
15. Permitotheryardandgardenworkto continuewhenirrigationistakingplace, asonlytheimmediateplantareasare wet.

3.1 DisadvantagesofDripSystems

1. Requirefrequentmaintenancefor efficientoperation.
2. Aresubjecttovandalismwhensystems arenotconcealed.
3. Havelimitedlifeafterinstallationdueto thedeteriorationoftheplastic componentsinahot,aridclimatewhen exposedtoultravioletlight.
4. Aretemporaryinstallationsandmustbe expanded or adjusted to the drip line as plantsgrow.
5. Aresubjecttodamagefromrodents (particularlygophersandmice),insects andhumans.

4.0 Some Researches on Drip irrigation in Nigeria

Fasinmirin *et al.*, (2009) investigated the water use and biomass yield of differentially irrigated *Amaranthus cruentus* at differentdevelopmentalstages: emergence/vegetative,fruiting andmaturity at *Akure,Nigeria.* Fieldexperimentswere conductedbetweenJanuaryandMarchof2005and2006.Theexperimentwasa2×3×3combination oftwoirrigationmethods (dripandsprinklersystems)three cropphenologicalstages (Emergence/vegetative,fruitingandmaturity),andthreewaterstresslevels.Arandomized complete blockdesign(RCBD)wasadopted.Soilmoisturestorageswithintherootzone depth(10-30cm)of *Amaranthus*werehighest(13.86and13.23cm)ondripplotsatthe71dayofyear(DOY)duringthe 2005and2006experimentrespectively. The highest evapotranspiration were 12.87 and 9.96 mm day^{-1} during 2005 and 2006 respectivelyonplotsirrigatedunderdripsystem.Thehighestandthelowestcropyieldwere13.94 and4.2tonha^{-1},respectivelyinplotsirrigatedunderdripirrigationsystem,and11.16and3.39tonha^{-1}, respectively in plots irrigated under sprinkler system Based on a two-year study, the pattern of soil water extraction differed among treatments.

Fasinmirin *et al.*, (2008) carried out anexperiment todeterminetheinfluence ofthreedrip irrigationregimesonpatternofmoisturedistribution withinthesoilprofileof*Amaranthus cruentus* field.Irrigations werecarriedoutat50KPa(Lowstress),60KPa(Mediumstress)and70KPa(Severe stress)levels.Thepatternofsoilwaterextractiondifferedsignificantly amongtreatments($P<0.05$).*A. cruentus*extractswater foritusedependingonavailablemoisturewithindepths oftherootzone.Fieldplot,10.0m x12.0minsizewaslaidoutusingtied-ridgeseach10.0mx0.4min dimension.The waterapplication methodadopted wasthegravity drip irrigation system.Irrigation waterwasdelivered tothe experimentalfieldusingdripemitterspaced1x 1m^{2}apart.There were pre-irrigation oftwo daysbefore planting ofthe crop.There- after, irrigation water treatmentswere imposed. The treatmentswere typified by the difference in the soilmoisture stressatwhich irrigationswere carriedout, resultsshowedthat the relationof soil moisture

tensionispositivewithrespecttosoilmoisture storage.Moisturedepletion decreases downthesoilprofile,hence,lowsoil moisture tensionswereobservedat the rootzonedepthof*A.cruentus*.Significantincrease in soil moisture storageattherootzonedepthofthecrop wascausedbyincreasedaccumulation ofsoilmoisture fromtheseriesofirrigations carriedout.

Mofoke *et al*.,(2006) designed an affordable continuous-flow drip irrigation system with the use of medi-emitter which was evaluated in Bauchi state -Nigeria with tomato as test crop. The system was designed to deliver the peak daily crop water requirementonacontinuousbasisthroughouttheday. Thecalculatedcontinuous-flowratewas9 dropsofwaterperminute.Thehydraulicdesignwasbasedonastepwiseuseoftheenergyequation. The system was constructed exclusively from cheap and locally available materials, incorporating a modified form of the medical infusion set as emitter. Results of the system's evaluationrevealedhigh ApplicationEfficienciesintheorderof95,96,96,and98%under continuous discharges of 9, 13, 17, and 21 drops/min respectively. The corresponding Irrigation Efficiencies were 94.0, 90.1, 91.0, and 88%. Measured Distribution Uniformity for the four treatmentswere90.0,91.4,93,and97%whiletheAdequacyofIrrigationwere92.0,93.1,94.0, and 98% for the four treatments in same order. Such high values of measured performance parametersindicateanexcellentexploitofthecontinuous-flowsystem.Emittercloggingwhich is a common menace with drip systems was controlled fairly well by two improvised low-cost primary and secondary filters results showed that hydraulic design and component selection of the affordable continuous-flow dripsystemoffersatisfactoryhydraulicperformance and adoptionofthemedi-emitter inparticular,contributesconsiderablyinofferinghighspatialuniformity.

EdogaRitaNgoziand M.O.Edoga (2006) in Zaria –Kaduna State Nigeria [made] an attempttodesigna dripirrigationsetfor smallvegetablegardens because theneedforanaffordablesmallscaleirrigationsystem inmostsmallgardensin Nigeriatodayisonincrease. Thedrip irrigation setdimensionally consistsofa main linediameterof12.7 mm,three lateral linesofdiameter19.05mmand emittersofdiameter1.5mmspaced60cmalong the laterallines. Theemittersdischargeratewasfoundtobe2.12litres/hourand thiswillhopefully completeoneirrigationofthearea (5 mx 10 m)designed for4 hoursatpeakconsumptiveuseperiods, employingtwo shiftsof thethreelaterals.Theavailability ofdripirrigationsetusingdurablelocalmaterialswillhelpgreatly to minimize the problemofhighcostof initialinvestmentwhichdiscouragesthe averagefarmer fromtaking dripirrigationtechniquedespiteitsnumerousadvantages.Thesystemdesigned andconstructedinthisstudy may beusedinlargeorsmallfarms.Itiswithinthetechnical competence and financialreach ofthefarmers.

Akinro *et al.,* (2011) in western Nigeria made an attempt to design and construct a gravitational drip irrigation system for plantain production. The system was used for two cropping seasons of 2006-2007 and 2007-2008. The designed water requirement for the plantain was computed as 7.85mm/day, average discharge value of emitter 3.82l/h, emission uniformity coefficient of emitter was 84.2%.

Ewemoje *et al*., (2010) developed a drip irrigation system using available materials. The system

consist of 4l/hr Netafim pressure- compensating emitters to irrigate 0.0015ha land where sweet corn was planted under variable water application, watering thrice per week resulted in the highest leaf area, plant height and root depth and weight, watering twice per week gave highest fresh weight and cob yield.

Paul *et al.* (2010) reported that drip fertigation with bucket kit could be particularly useful for small scale vegetable production during dry season in Southern Nigeria. Yohanna (1997) in Maiduguri – Borno State used canvas material with varying lengths to obtain specified flow rates; also Oyebode *et al*., (2011) in Zaria evaluated the hydraulic characteristic of a gravity drip irrigation kit**.**

Also, the savanna church of Christ School of Biblical Studies Jos- Nigeria even though is a religious body started drip irrigation farming program, now they organize seminars for interested persons even outside the state (www.savannachrist.com)
However, adopting drip irrigation technology is on-going in Nigeria in places like the Agricultural Services and Training Centre Jos-Plateau state inaugurated on the 10th February 2012, an Israeli company called SEC in conjunction with plateau state government are raising the Agricultural production, boosting yield and improving the quality of produce with the use of conventional drip and low-cost drip irrigation system.

The state of Israel in partnership with the Niger state Government has commissioned a drip irrigation project for vegetable production in a bid to improve food security and socio-economic status of the people. The project covers a land of 2.5 hectares in Lapai Gwari Village near Minna to depend on drip water pipes which were laid round the farm (Punch Newspaper, 10th may 2012).

5. CONCLUSION

Today it is more important than ever to use water resources wisely and to irrigate intelligently. Consequently, many farmers have turned to drip irrigation and have enjoyed improved profitability by increasing crop yield and quality while at the same time reducing costs from water, energy, labor, chemical inputs and water runoff. Drip irrigation presents an attractive prospect for the advancement of agricultural productivity amidst scarce resources in Nigeria. Extension officers should provide information, demonstrations and guidance to farmers where needed, while financial institutions and State government in collaboration with western bodies (like what is happening in Plateau and Niger state and Israel) should offer farmers credit on favorable terms to invest in appropriate irrigation technology. Such technology will only be accepted if it produces adequate returns, that is to say, if its benefits clearly justify the costs.

REFERENCE

Akinro, A.O, Olufayo A.A,P.G Oguntunde (2011). Design, Construction and Performance Evaluation of drip Irrigation System for plantain production in a tropical Environment of Western Nigeria.www.cabdirect.org accessed on 3rd August 2012.

Chitsiko, R. J. and K.T Mudima (2002). Adapting Modern irrigation technologies for use by Small holder farmers- the Zimbabwean experience. Paper presented at the seminar: Smallholder land and water Management Systems- Sharing Lessons from Experiences in Africa and Asia, 1-5 July 2002, Bangkok, Thailand, pp:11

EdogaR.N, M.O.Edoga (2006). DesignofDripIrrigationSetFor SmallVegetableGardens Not.Bot.Hort.Agrobot.Cluj,XXXIV

Ewemoje,T.A;S.A lateef, S.O Afolayan (2006). Performance Evaluation of drip Irrigation System Sweet Corn. Journal of Applied Science, Engineering and Technology. Vol 6 page 16-21

FasinmirinJ.T, A. A. Olufayo, P. G. Oguntunde,A. M.Oguntuase (2009). Parametrizing Simple Model between Yield and Evapotranspirationfor Amaranthus cruentus under Drip and SprinklerIrrigations. InternationalJournalofPlantProduction ISSN:1735-6814(Print),1735-8043

FasinmirinJ.T.andA.M.Oguntuase (2008)Soil Moisture Distribution Pattern in *Amaranthus Cruentus* Field Under Drip Irrigation System.AfricanJournal ofAgriculturalResearchVol.3(7),pp.486-493

Frausto ,K. (2000). Developing Irrigation Options for Small farmers. Report for thematic Review IV.2: Assessment of Irrigation Options. IDE, USA

FAO. (2004). The State of Food Insecurity in the World: Monitoring progress towards the World Food Summit and Millenium Development Goals. Food and Agricultural Organisation of The United Nations, Rome.

Karlberg, Lo.and F.W.T. Penning de Vries, 2004.Exploring potentials and constraints of Low cost drip irrigation with saline water in sub-saharan Africa.Phys.Chem.Earth, 29:1035-104

Mofoke,A.L.E., J.K. Adewumi and O.J., Mudiare,(2006). Design Construction And Evaluation of a Continuous-Flow drip Irrigation System. Unpublished PhD Thesis in Department Of Agricultural Engineering, ABU Zaria

Mehari Halle, A., H. Depeweg, et al. (2003). "Smallholder drip irrigation technology: Potentials and constraints in the highland of Eritrea." Mountain Research and Development 23 (1): 27-31.

Manaktala, S. (2005). "IDE (India)'s market creation approach to development." Small Enterprise Development 16 (2): 36-43.

Maisiri, N., A. Senzanje, et al. (2005). "On farm evaluation of the effect of low cost drip irrigation on water and crop productivity compared to conventional surface irrigation system." Physics and Chemistry of the Earth 30 (11-16 SPEC. ISS.): 783-791

Marr,CharlesW.,Lamont,WilliamJ.Jr.,andRogers,Danny.Dripirrigationforvegetables. CooperativeExtensionService.KansasStateUniversity.Manhattan,Kansas Polak Narayanamoorthy,A.(1996). Evaluating DripIrrigationSysteminMaharashtra.Mimeograph SeriesNo.42,Agro-Economic ResearchCentre,GokhaleInstituteofPoliticsandEconomics,Pune,Maharashtra,March,pp.viii+114

Nakayama, F.S., Bucks, D.A., 1986. Trickle Irrigation for Crop Production Design, Operation and Management, Developments in Agricultural Engineering 9, Elsevier, Amsterdam, 383 p.

Nanes, P B. (1997). "A low cost drip irrigation system for small farmers in developing countries." Journal of the American Water Resources Association 33 (1):119-124.

Oyebode, M.A; H.E Igbadun and S.C Kim (2011). Evaluation of Hydraulic Characteristic of a Gravity Drip Irrigation Kit. Proceedings of the 11th International Conference and 32nd Annual General Meeting of the Nigerian Institution of Agricultural Engineering (NIAE Ilorin 2011).Vol.32:851-856

Phene, C.J., Howell, T.A., 1984. Soil sensor control of high frequency irrigation. Trans. of ASAE 27(2), 392-396.

Phene, C.J., Sanders, D.C., 1976. High-frequency trickle irrigation and row spacing effects on yield and quality of potatoes. Agron. J. 68, 602-607.

Postel, S., P. Polak, et al. (2001). "Drip irrigation for small farmers: A new initiative to alleviate hunger and poverty." Water International 26 (1): 3-13.

Paul B.O,P.O Afiong, B.I Otobong, I.E Essien (2010). Drip Fertigation Effects on Vegetables (Cucumber) Grown on Tropical Acid sands. Research Journal of soil and Water Management Vol.1 Issue 2 page 61-67.

Sandra, P;P. Polak; F. Gonazales and J. Keller (2001). Drip Irrigation for Small Farmers: A New Initiative to Alleviate Hunger and poverty. International Water Resources Association, water International, Volume 1, page 3-13.

Victor, B.E; Reyes. M.R; Robert.Y (2008). Effect of hydraulic head and slope on water distribution uniformity of a low-cost drip irrigation system. Sustainable Agriculture and Natural resource Management collaborative support programme, Office of International Research, Education and development Virginia Tech

www.punchng.com accessed on 10th may 2012.

www.savannachrist.com/drip-irrigation accessed on the 3rd August, 2012.

Yohanna, A.D. (1997). Design, Construction and Characterization of a Canvas Trickle Irrigation Line Source Emitter. Msc. Research Thesis. Dept. of Agric. Engr. University of Maiduguri, Nigeria.

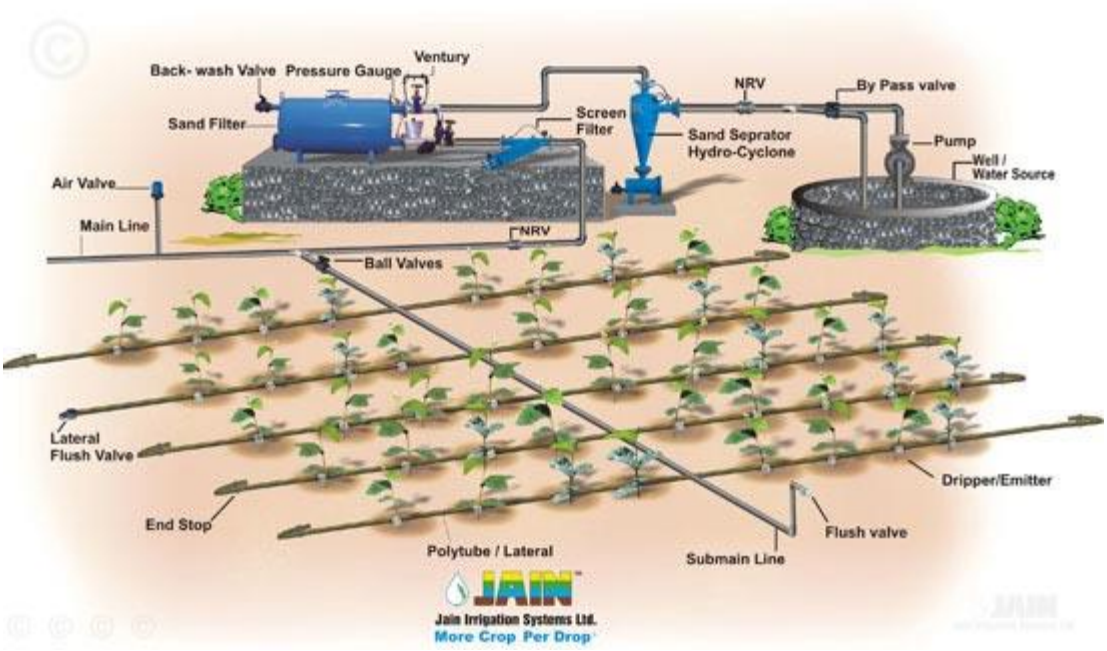


Fig 1. Conventional drip irrigation system a product of Jain

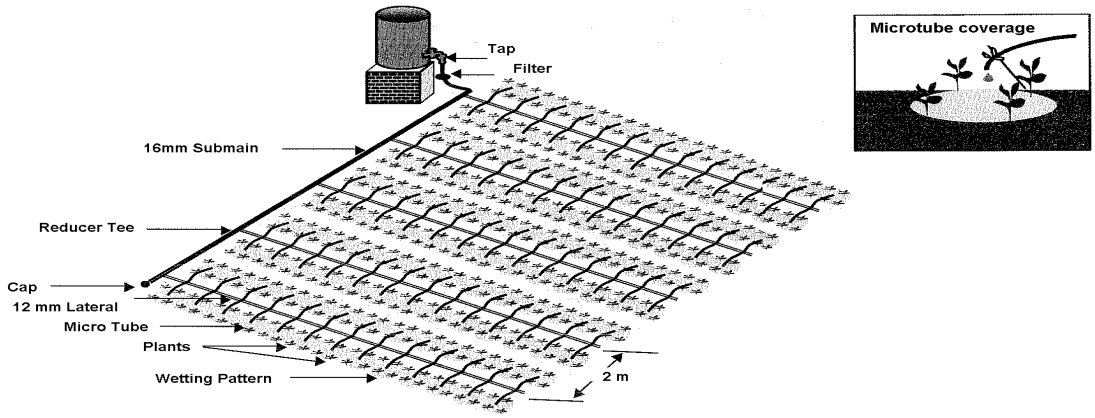


Fig 2.Low-cost micro-tube drip irrigation system



Fig 3. Field laid with drip lines

MORINGA OLEIFERA FOR WATER PURIFICATION

G.I. Ezenne and C. S. Abana

Department of Agric and Bioresources Engineering

University of Nigeria, Nsukka

E-mail: ifyglory77@yahoo.com

ABSTRACT

Water born diseases are one of the main problems in developing countries and about 1.6 million people are compelled to use contaminated water. However in many communities of these countries water clarification methods like flocculation, coagulation and sedimentation are often inappropriate because of the high cost and low availability of chemical coagulants. The use of natural materials of plant originto clarify turbid water that do not pose a threat to human health is of interest to us. Among all the plant materials that have been tested over the years, the seeds from Moringaoleifera have been shown to be one of the most effective as a primary coagulant for water treatment. Hence, this study reviews uses of moringaoleifera as well as the methods involved in water treatment with moringaoleifera. Also presented in this work are moringaoleifera water purification results and comparison between the moringaoleifera and alum in water purification. Moringaoleifera effectiveness for treating water has been conducted when comparing its coagulative properties with synthetic coagulants. It was found to be much more effective in purifying water than alum. Also, toxicological assessments indicated that using Moringa oleifera seeds as a primary coagulant do not pose a human health threat unlike other synthetic coagulants.

1.0 Introduction

Access to water is a basic human necessity unavailable to hundreds of the developing communities every year. Yet the search for water and the effects of unsafe water and poor sanitation is an enormous burden on their daily lives especially for most rural communities in Nigeria and other West African countries where the situation is rather increasing, thus little prospects for development. More than half of all illnesses and deaths among children are caused by germs, which get into the mouth via water and food. The world Health Organization has estimated that up to 80% of all the disease and sickness in the world is caused by inadequate sanitation, polluted water or unavailability of water. About 1.2 billion people still lack safe drinking water and more than six million children die from diarrhea in developing countries every year Muyibi (2005). Water borne disease still kill on the average 25,000 people every day in developing countries and millions suffer the debilitation effects of these diseases. About 75% of the present world population lives in the developing countries of the world. According to Muyibi (2005), about 80% of all illnesses in developing countries are water related e.g. cholera, dysentery, diarrhea, etc. Therefore, safe drinking water is essential to the health and welfare of community and water from all sources must have some of purification before consumption Muyibi (2005). Developing countries also pay a high cost to import chemicals including polyaluminumchloride and alum for water treatment purpose Ghebremicheal (2005). This is the reason why these countries need low cost methods requiring low maintenance and skill. Based on this, an appropriate treatment technology can render this poor water resource into safe portable

water. However, conventional technology may not be appropriate for those communities in terms of economics, availability, and operational constraints. This study exposes uses of moringaoleifera and how it can be used in water purification. The work also compares the efficiency of using *Moringa oleifera* as an effective coagulant to traditional alum in removal of turbidity and improving bacterial quality in water.

2. Moringa Oleifera

The *Moringa oleifera* tree basically, originated from Agra and Oudu in the northwestern region of India, south of the Himalayas and is now cultivated across the whole of the tropical belt. *Moringa oleifera* tree was first described as medicinal herb. In Pakistan, itis locally known as "Sohanjna" and only two species of *Moringa (Moringa concamensis and Moringa oleifera*) are reported from Pakistan for centuries. *Moringa* has been taken to several semi-tropical and topical locations. People in the India sub-continent have long used *Moringa* pods for food. The edible leaves have also been eating throughout Western Africa and parts of Asia. It was originally an ornamental tree in Sudan, planted during British rule. That was where Dr. SamiaAlazhariaJahn's (a German scientist) carried out a laboratory test and confirmed the presence of a very efficient coagulant in seeds of *Moringa oleifera* Schwarz (2000).

Moringa oleifera is a fast growing, aesthetically pleasing small tree adapted to arid, sandy conditions. It has a spreading, open crown of drooping, fragile branches, feathery foliage of tripinnate leave and thick, corky whitish bark. The fruits are pendulous, linear, three-sided pods with nine longitudinal ridges, usually 20 to 50cm long. Each pod usually contain up to 26 seeds. They are dark-green during their development and take approximately 3months to mature after flowering they turn brown on maturity, and split open longitudinally along the three angles and then, releases the seeds. The seed is 1cm in diameter. The seeds are dried, rounded or triangular in shape. *Moringa oleifera* is usually deep rooted. *Moringa oleifera* can be easily established by cutting or by seed. Seeds can be sown either directly or in containers and no seed treatment as required. It requires an annual rainfall of 250-1500m. It is a tree of hot and semi-arid region. Also, it is well adapted to humid and wet conditions with annual rainfall of 3000mm.However it does best where temperature ranges from 26 to 40^{o}C and annual total rainfall at least 500mmSchwarz (2000).

Moringa oleifera is susceptible to several insect pests. These include the barkeating caterpillar, *Indarbelaquadrinotata*, the green leaf caterpillar, Noorda Bliteralis, the hairy caterpillar, *Eupterote Molifera,* and the budworm, *NoordaMoringa*.

Uses of Moringa Oleifera

The seeds of the Moringa Oleifera plant are among the most nutritious and useful botanical products available. These versatile seeds can be used in a variety of ways such asmoringa seeds in traditional medicine, modern medical uses, nutritional value, water purification, agriculture, and a source for biofuel.

Moringa seeds in traditional medicine: the seeds of the moringa plant have been used in "Ayurveda" medical practice for centuries to treat a variety of ailments and to improve overall health in patients. The antibiotic properties of moringa seeds make them valuable in poultices and topical treatments for bacterial infections and other conditions of the skin. Taken internally, moringa seeds have traditionally been used to reduce the frequency of epileptic fits and to treat

arthritis and rheumatoid disorders. Moringa seeds are also recommended by traditional practitioners to treat a variety of sexual dysfunctions and to improve sex drive in both men and women.

Modern medical uses: the antibiotic properties of moringa seeds have been proven in laboratory testing. Moringa seeds can be used to treat fungal infections as well due to the presence of pterygospermin, a naturally occurring antibiotic present throughout the moringa plant. Additionally, the high protein and iron content of these seeds make them a valuable resource in combating malnutrition and anemia in developing regions of the world.

Nutritional value: Moringa oleifera seeds are eaten like green peas. The seeds offer concentrated nutrients including amino acids, proteins and a wide range of vitamins and minerals, making them an outstanding supplement for stressed and hurried individuals and a solid source of nutrition for undernourished populations around the world. The nuts can be served fresh or dried and often are pressed to remove the oil they contain, which is useful for cooking and can be added to other dishes to boost their nutrient content as well.

Water purification: Moringa oleifera seed powder is particularly effective in purifying water. This is important in many societies, where the only drinking water available may come from a dirty river or lake. The Moringa oleifera seed powder removes dirt by joining with the particles and sinking to the bottom. It also is extremely effective in removing harmful bacteria from bodies of water. Moringa oleifera seed powder is much more economical, and arguably, safer than aluminum sulfate and other chemicals traditionally used in water purification. When crushed and added to turbid water, moringa seeds can serve to purify it for drinking and other uses Sarpongand Richardson (2010). This cleansing property is the result of the coagulating nature of the moringa seed, which can speed water clarification and allow water to settle and become safe to drink much more quickly. The use of moringa seeds in water purification is expected to provide healthier, safer drinking water for many areas of the world where technologically advanced methods are not available.

Agriculture: ground and defatted moringa seeds can be used to supplement animal feed or as fertilizer for crops and enrichment of soil, allowing farmers and ranchers to enjoy increased production and improved results from their agricultural endeavors.

A source for biofuel: because moringa seeds are rich in natural oils, they have been considered as a potential source for biofuel materials. Newer extraction techniques may make this even more profitable and prevalent as fossil fuels supplies continue to shrink.

3. Water Treatment with Moringa Oleifera

Coagulation with Moringa seeds

Generally, coagulants are used for (physical and chemical) purification of turbid raw waters. At very high turbidity the water can no longer be adequately treated by using filters. Coagulants have to be applied to transform water constituents into forms that can be separated out physically. In large scale treatment plants Aluminum Sulphate is used as a conventional chemical coagulant. As an alternative to conventional coagulants, Moringa oleifera seeds can be used as a natural coagulant (primary coagulant) in household water treatment as well as in the community water treatment systems. Natural coagulant properties were found in 6 different moringa species by

laboratory studies carried out by Schwarz(2000).The seed kernels of Moringa oleifera contain significant quantities of low molecular-weight, (water-soluble proteins) which carry a positive charge. When the crushed seeds are added to raw water, the proteins produce positive charges acting like magnets and attracting the predominantly negatively charged particles (such as clay, silk, bacteria's, and other toxic particles in water). The flocculation process occurs when the proteins bind the negatives charges forming flocs through the aggregation of particles which are present in water. These flocs are easily removed by settling or filtration. The material can clarify not only highly turbid muddy water but also water of medium and low turbidity. The level of turbidity influences the required time for the flocculation. As with all coagulants, the effectiveness of the seed may varies from one raw water to another. The practical application of dosing solutions is exactly the same as for all other coagulants.

Preparation of the coagulant solution

Seed solutions may be prepared from either seed kernels or the solid residue (presscake) obtained following extraction of seed oil. Moringa seeds, seed kernels or dried presscake can be stored for long periods but moringa solutions for treating water should be freshly prepared each time. In general, 1 seed kernel will treat 1 liter of water.

Dosage rates

According to Doerr (2005) the dosage rates should be applied in the following ways:

Low water turbidity NTU<50 1 seed per 4 liters water

Medium water turbidity NTU 50-150 1 seed per 2 liters water

High water turbidity NTU 150-250 1 seed per 1 liter water

Extreme water turbidity NTU >250 2 seeds per 1 liter water

Procedures

- Seeds is obtained from Moringa oleifera plantation
- The seed is air dried for five days and decorticated to remove the white kernel.
- The Seed kernel is pulverized with an electric blender and sieved to obtain a fine particle.
- The grinded seed is subjected to solvent extraction to remove some percentage of oil
- The seed extracts is dissolved into distilled water (H_20)
- A 1M NaCl solution (Brine) is added into 3.5kg of Moringa seed
- The NaCl solution + distilled water + powder is stirred for 30 minutes at room temperature (around 25ºC). No pH modification was needed, as natural pH 7 is achieved.
- The impurities of the water sinks to the bottom as the result is a clear, milky-like liquid in the coagulation – flocculation chamber
- Then the water is further clarified and filtered through the slow sand water filters tanks
- The well purified water 'clean water' is stored at the treated storage tank for consumption and storage.

4. Moringa Oleifera Water Purification Results

Moringa oleifera purifies water by coagulating the impurities of the water, sinks it to the bottom as the result is a clear, milky-like liquid in the coagulation – flocculation chamber after coagulation process, then the water is further clarified and filtered through the slow sand water filters tanks. The well purified water (clean water) is stored at the treated storage tank for consumption and storage. Moringa oleifera also serves as a microbial agent during water treatment as a result making the water free from microorganism infestation which renders water unfit for drinking.

As a coagulant: Moringa oleifera contain significant quantities of low molecular-weight, (water-soluble proteins) which carry a positive charge. When the crushed seeds solution are added to raw water, the proteins produce positive charges acting like magnets and attracting the predominantly negatively charged particles (such as clay, silk, bacteria's, and other toxic particles in water)

As an antimicrobial agent: the frequency of life threatening infections caused by consumption of untreated water has increased worldwide and is becoming an important cause of mortality in developing countries Al-Bari et al. (2006). Microorganisms contaminating water can cause gastroenteritis or inflammation of the stomach and intestinal lining. These include typhoid caused by Salmonella typhii, gastroenteritis caused by Escherichia coli and cholera caused by Vibrio cholerae. Conventional water disinfectants like chlorine have been used, but due to high cost and unavailability, households in developing countries, use unpurified water leading to increased cases of water borne diseases Ouma et al. (2005). According to World Health Organization, microbial resistance to conventional water treatment mechanisms is on the rise and medicinal plants such as Moringa oleifera offer a good source of alternatives since Over 80% of the population in rural areas where water purification is rarely practiced due to high cost and unavailability of conventional purifiers can afford the medicinal plant alternative for water purification.

A study carried out in India, in which crude ethanol extract of M. oleifera were tested against E. coli, S. typhii, V. cholera, Shigelladysentriae and Pseudomonas aeruginosa, showed activity against E. coli only Shekhar et al., (2000). It is observed that water soluble extracts of M. oleifera had antibacterial activity against E. coli. In humans, Salmonella are the cause of two diseases called salmonellosis: enteric fever (typhoid), resulting from bacterial invasion of the bloodstream, and acute gastroenteritis, resulting from a food borne infection/ intoxication. Study has shown that methanol extracts of M. oleifera had antimicrobial properties against S. typhii. It was observed that S. typhii was the most sensitive to Moringa extracts as compared to V. cholerae and E. coli. This is an indication that the extracts can be effectively used to treat water contaminated with S. Typhii Arama (2011). Cholera is potentially epidemic and life-threatening and transmission of V. cholera in humans occurs through contaminated water and food. To prevent it from spreading, water and food must therefore be kept clean and the domestic water can be treated using M. oleifera extracts. Studies have shown that the inhibition activity against V. cholera for Moringa extract is observed at the highest concentrations of 0.4 mg/ml. This indicated that V. cholerae was the most tolerant bacteria species to Moringa extract as compared to E. coli and S. typhii.

5. Comparison between the *Moringa Oleifera* and Alum in water purification

Moringa oleifera was compared with alum in waste water treatment and its effects indicated that about 90% of the particles in the samples leading to a clear supernatant. The coagulation effect was for better in heavily polluted water than in less polluted water Muyibi, (2005).Unlike with Alum, flocs settlement in Moringa treated samples was slower when the seeds were directly dispersed into the water but when the seeds were packed into muslin sackcloth and dipped into the sample, flocs settlement was faster and was as good as with Alum. Harristoy et al., (2005) said that coagulative effect of *Moringa oleifera* seeds was even better than with alum and this can be explained with the fact that *moringa oleifera* seeds exhibits strong antimicrobial activity. For instance, the raw untreated stagnant water from Gutter had an initial total bacterial counts too numerous to count, which reduced to only 2,700 colony forming units per ml when treated with *Moringa oleifera* seeds as opposed to 8000 colony forming units when treated with Alum. In Sudan, dry *Moringa oleifera* seeds are used in place of alum by rural women to treat highly turbid Nile water Jahn, (1986).

Alum exhibited a minimal effect on bacterial load of the samples. The may be due to the fact that some bacteria attached to the surface of the particles that eventually settles with them. To further prove this point, a 100 mg/mol of alum was tested on E.coli isolated from the waste water sample and no inhibition was noticed meanwhile, a 100mg/mol of (bulk) methanol extract of *Moringa olifera* seeds when tested showed an appreciable inhibition of the same E.Coli.

Moringa oleifera has shown no bad effect on the health of the consumers, and as well less expensive to obtain or purchase unlike the alum Jahn (1994). Also, in terms of their antimicrobial effects, the study of *Moringaoleifera* seeds paste for water purification yielded a steroidal glycoside, strophantidin, a bioactive agent in the seed. The seed paste was found effective in clarification and sedimentation of inorganic and organic matter in raw water there by reducing total microbial and conform counts by 55% and 65% respectively, in 24hours compared to alum with 65% and 83% reduction Compaore,(2011). Table 1 shows differences between water coagulation with *Moringa oleifera* seed extract and Alum is summarized in a tabular form below:-

Table 1: Differences between water coagulation with *Moringa oleifera* seed extract and Alum is summarized in a tabular form below:-

Parameters	**Moringa oleifera seed extract**	**Aluminum Sulphate**
Destabilization.	Cationic polyelectrolyte	Al^{3+}
Efficiency at low turbidity	Failing below 30 NTU	Still satisfactory 3NTU
Support of aggregation.	None	Adsorption at Al (OH) 3flocs.
Mineralogical nature of suspended matter	Doses about 50% lower if moutmorillonite clays are present (Blue Nile)	Minor impact on optimal doses.

Pollution by organic matter	Great impact on doses and additional organic bad.	Minor impact on optional doses

Source: Compaore, (2011).

Problems faced in the use of chemical coagulate

Some of the chemicals though are useful in water treatments' but also contribute immensely in one problems or the other to the consumers. Some of these chemicals such as alum, chlorine, e.t.c. cause a great potential health and environmental problems in their use as chemical coagulants'. Some of these problems includes:-

- Aluminum has been indicated to be a causative agent in neurological diseases such as pr-senile dementia.
- There is a great fear that the ingestion of aluminum ions may induce Alzheimer's disease. Muyibi, (2005).
- There is the problem of reaction of alum with natural alkalinity present in water leading to reduction of pH and low efficiency in coagulation of cold waters.
- Under-dosing chemicals so as to meet the increasing water demand leading to production of poor quality drinking water.
- Using alum as well other metallic salt coagulants produces large sludge volumes which are also non-biodegradable.
- Ferric salts and synthetic polymers have also been used as coagulants but with limited success because of the same disadvantages manifested in the use of aluminum salts.
- Aluminum is regarded as important poisoning factor in daily encephalopathy Yaramadi, (2009).

6. CONCLUSION

Moringa oleifera seeds treat water on two levels, acting both as a coagulant and an antimicrobial agent. It is generally accepted that Moringa works as a coagulant due to positively charged, water-soluble proteins, which bind with negatively charged particles (silt, clay, bacteria, toxins, etc) allowing the resulting "flocs" to settle to the bottom or be removed by filtration. The antimicrobial aspects of Moringa continue to be researched. Findings support recombinant proteins both removing microorganisms by coagulation as well as acting directly as growth inhibitors of the microorganisms. Moringa oleifera effectiveness for treating water have been conducted when comparing its coagulative properties with synthetic coagulants e.g. alum. It was found to be much more effective in purifying water than alum. Also, toxicological assessments indicated that using Moringa oleifera seeds as a primary coagulant do not pose a human health threat unlike other synthetic coagulants. In addition, coagulation efficiency of Moringa oleifera decreases with an increase in storage duration because it is highly biodegradable with a short shelf life. Other studies have also shown that the coagulation efficiency can be increased by extracting its active components using salt. Studies carried out to determine the potential risks associated with the use of moringa seeds in water treatment have it that no evidence has found

that the seeds cause secondary effects in humans, especially at the low doses required for water treatment.

REFERENCE

Al-Bari M, Sayeed M, Rahman M, Mossadik M. (2006). Characterization and antimicrobial activities of a phenolic acid derivative produced by Streptomyces bangladeshiensis, a novel species collected in Bangladesh. Res. J. Med. Med. Sci., 1: 77-81.

Arama P. F. (2011).Harvesting surface rainwater purification using Moringa oleifera seed extracts and aluminum sulfate Journal of Agricultural Extension and Rural Development Vol. 3(6), pp. 102-112,

DoerrB. (2005). Moringa water treatment. An echo technical note, USA

Compaore, W.R. (2011). Chemical composition and antioxidative properties of seeds of Moringa oleifera and Pulps of Parkiabiglobosa and Adansonia digitata commonly used in food fortification in Burkina Faso. Current Research Journal of Biological Sciences. 3 (1): 64-72.

Ghebremicheal, K.A. (2005). A simple purification and activity assay of the coagulant protein from Moringa oleifera seed. Water Research. 39:2338-2344.

Harristoy X., Fahey J., Scholtus I., Lozniewski A. (2005). Evaluation of antimicrobial effects of several isothiocyanates on Helicobacter pylori. Plantamedica, 71: 326-330.

Jahn V., (1986). Effect of water coagulation by seeds of Moringa oleifera on bacterial concentrations. J. Trop. Med. Hyg., 90: 101-109.

Jahn V., (1994). Antibacterial activity of leaf juice extracts of Moringaoleifera against some human pathogenic bacteria. J. Nat. Sci., 8: 219-227

Muyibi, S. (2005). Treatment of surface water with Moringa oleifera seed extract and alum - a comparative study using a pilot scale water treatment plant. International journal of environmental studies. 60 (6): 617-626.

Ouma Y, A. Sharby, and R. Tateishi (2005). Dynamism and abundance of water hyacinth in the Winam Gulf of Lake Victoria: Evidence from sensing and seasonal-climate data. Int. J. Environ. Stud., 62: 449-465.

Sarpong, G. and Richardson, C. P. (2010). Coagulation efficiency of Moringa Oleifera for removal of turbidity and reduction of total Coliform as compared to aluminium sulphate.African Journal of Agricultural Research. 5 (21): 2939-2944.

Shekhar C, R. Shukla, A. Kumar, and N. K. Dubey (2000). Laboratory of herbal pesticides, Centre of advance study on botany, Banaras Hindu University Varanasi India. Eur. J. Clin. Microbiol. Infectious Dis., 6:23-28.

Schwarz, D. (2000). Water clarification using Moringa oleifera.Technical information W1e, Gate information service, Eschborn, Germany. http://www.gtz.de/gate/gateid. afp. (accessed on 25th February, 2010).

Yarahmadi, M. (2009). Application for Moringa oleifera seed extract and Polyaluminium Chloride in water treatment. Journal of World Applied sciences. 7 (8): 962-967.

INFLUENCE OF RICE HUSK ON BULK DENSITY OF FADAMA SOILS

Abubakar A. S[*] and Abdullahi A. S

Agricultural and Bio-Resource Engineering Programme,
Faculty of Engineering, Abubakar Tafawa Balewa University, Bauchi, Nigeria
[*]*sunusiabubakar@yahoo.com**corresponding author***

ABSTRACT

The influence of rice husk on the bulk density of compacted Fadama soils was studied under laboratory condition. The bulk density of soils decreased with increase in the rice husk content even when compaction is increased. Two sets of soils / rice husk mixture at 0 – 400 g level were compacted from 0 to 8 compaction blows. The bulk density of set one was found to decrease from 1.487 g/cm^3 to 1.227 g/cm^3 while that of set 2 decreases from 1.485 g/cm^{3}to 1.289g/cm^3 respectively.

Keywords: Rice husk, bulk density, Fadama soil, Bauchi

1.0 Introduction

Soil compaction is defined as the densification of unsaturated soil due to reduction in air volume without change in mass wetness (Hillel, 1971). During must agricultural practices, mechanized cultivation disturbs the soil, causing fragmentation, compaction and displacement (Roger-Estrada et al, 2000). The intensity of compaction can be readily interpreted with high bulk density of a specific soil type (Goldsmith et al, 2001). The effect of changes of structure following tractor wheel passage during cultivation practices on agricultural soils may increase bulk density and soil strength, while reducing aeration and water movement in the root zone. If soil is compacted to the level that plant growth is impaired the compaction must be alleviated using several measures intended to returning satisfactory growth condition. One of these measures is the incorporation of organic matter into the soil. Organic farming is a rapidly growing system of agricultural production all over the world, and the developing nations of the tropics are no exception. Either through choice or necessity, farmers produced crops for consumption, or more importantly for sale locally or as an export item (Joergensen, 2002). However, tropical soils generally have low organic carbon contents (Hartemink, 2003), and incorporation of organic matter in soil is of primary importance in maintaining soil fertility, productivity and sustainability, especially in organic farming systems (Dick and Gregorich, 2004).

Kuchenbuch and Ingram (2004) reported that bulk density, an important parameter related to root development was found to decrease, when organic materials were incorporated in to the soil. The water holding capacity of the soil increases with the incorporation of organic matter, especially the slower decomposing rice husk. However, Hartemink, (2003) show that the beneficial impact of organic matter in moisture retention declined with time, possibly due to the decomposition of the material in the warm climate of the dry season (Mean temperature 32.5°C). Large quantities of rice hulls are produced annually and with very high hills around the milling centers Figure 1. Irregular disposal and frequent burning of this waste constitutes environmental hazards to both farmers and other inhabitants, Ogbodo, 2010. Burning results to atmospheric pollution, nutrient loss and it may be a cost-effective method for husk disposal as it reduces pest and disease

populations (Dobermann and Fairhurst 2002). Rice residues can be used to improve properties of soil. Ogbodo (2010) also indicates that apart from its major role in supplying nutrients, crop residues (rice chaff) used as mulch have the potentials to regulate temperature, conserve soil moisture, minimize erosion and result in improved soil productivity. Mulching also has its benefits in terms of weed suppression. Weeds are major problems in most organic farming systems and the application of the organic matter, especially the slow decomposing rice husk, reduced weed populations significantly. The impact of mulch was found to be low due to the more rapid decomposition; although surface application reduced the weeds to a greater extent than when incorporate (Bond and Grundy, 2001). This becomes imperative in the tropics, where soil organic matter is low and where the organic matter decomposes rapidly due to the warm and dry climatic conditions. This paper determines the influence of rice husk incorporation on bulk density of Fadama compacted soils.



Fig. 1: Heap of rice hulls near milling centre

2.0 Materials and Method

a. Study site and sample preparation

Bauchi is geographically located at about 10^{o}22'N and 0947'E with elevation of 609.5m above sea level. It is situated in the Northern Guinea savannah ecological zone of Nigeria. Soils samples were brought from Fadama location at ATB University farm and allowed to dry, ground and sieved through 2mm sieve. The rice husk was brought from Wunti market milling centre, Bauchi. Cans of 100.2mm diameter, 13.2 cm heights and 71g weight were used. For each set 800 g of soil are mixed with 0, 100 g, 200 g, 300 g and 400 g rice residue at 0 to 8 compaction blows. The soil samples were compacted with 2.5 kg standard proctor.

b. Soil - husk mixture and compaction proportion

Table1 shows the two sets of soil - husk mixture and their various compaction levels.

Table 1: Rice husk proportion in 800 g soil

Set N0	Compaction level (blows)	Husk (g)
A	2	100
B	4	200
C	6	300
D	8	400
E	0	0

c. Bulk density determination

The bulk density of each of the content was determined using the following relationship

$$BD = M/V \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where:
BD= bulk density, g/cm^3
M= mass of soil, g
V= volume of the container, cm^3

3.0 Results and Discussion

Table 2. shows the bulk density of the soil as affected by incorporating rice husk. It was observed that bulk density decreases with increase in the husk level. The results showed decreased in bulk density with increase in quantity of rice husk even when compaction is increased. This indicates that the rice husk reduced the adverse effect compaction on Fadama soils. In set 1, bulk density decreases from 1.487g/cm^3 to 1.227g/cm^3 while in set 2 it decreases from 1.485g/cm^3 to 1.289g/cm^3 at husk level of 0g and 400g respectively. The results showed no much variation in BD between soils under the same treatment.

Table 2: Bulk density BD as influence by rice husk

Compaction (blow)	husk (g)	BD (g/cm^3)	
		Set 1	Set 2
0	0	1.487	1.485
2	100	1.438	1.433
4	200	1.408	1.406
6	300	1.384	1.315
8	400	1.277	1.289

4. CONCLUSION

The experiment conducted on the interaction of rice husk, and compaction, reveals that great influence is impacted on the soil bulk density by incorporation of the rice husk in to the soil. The

husk lowered the effect of compaction as indicated by the decrease in bulk density with increase in the husk level. However at some level of compaction and husk proportion the compaction is not influenced by the rice husk. It can be concluded that the destruction of soil structure of Fadama soils caused by trafficking machinery can be greatly reduced by the incorporation of rice husk into the soil.

REFERENCE

Bond, W and Grundy, A. C. (2001). Non chemical weed management in organic farming systems. Weed Research 41: 383 – 405

Dick, W. A. and Gregorich, E. G. (2004). Developing and maintaining soil organic matter levels. In managing soil quality: Challenges in modern agriculture. (P Schjonning et al ,eds) p 103 – 120 CABI, Wallingford, UK

Dobermann, A. and Fairhurst, T. H. (2002) Rice Husk Management Better Crops International, Vol. 16, Special Supplement

Hartemink, A. E., (2003): Soil fertility decline in the tropics – With case studies on plantations. CAB International. Wallingford, U.K.

Hillel D. (1971). Soil and Water: Physical and process. Academic Press New York 431p

Joergensen, R. G. (2002) Challenges to organic farming and sustainable land use in the tropics and subtropics. Journal of Agriculture of the tropics and Subtropics 103:103-105

Kuchenbuch, R.O.and Ingram, K.T. (2004). Effects of soil bulk density on seminal and lateral roots of young maize plants (Zea mays L). Journal of Plant Nutrition and Soil Science, 167:229 – 235

Ogbodo, E. N. (2010) Effect of Crop Residue on Soil Physical Properties and Rice Yield on an Acid Ultisol at Abakaliki, Southeastern Nigeria Research Journal of Agriculture and Biological Sciences, 6(5): 647-652, 2010

Roger-Estrada J., Richard D., Boizard H., Boiffin J., Caneil J., Manichon H. (2000). Modelling structural changes in tilled topsoils over time as function of cropping system. Eur J. Soil Sci., 51 : 455-474

Goldsmith W., Silver M M., Fischenich C. (2001). Determining optimum degree of soil compaction balancing mechaniacal stability and plant growth capacity. EMRRP-SR-26.

POTABLE WATER STORAGE AND DISTRIBUTION SYSTEMS IN ENUGU URBAN

J. C. ADAMA[1] and G.O. CHUKWUMA[2]

[1]Department of Agricultural and Bioresources Engineering, Michael Okpara University of Agriculture, Umudike, Abia State.

[2] Department of Agricultural and Bioresources Engineering,

Nnamdi Azikiwe University Awka, Anambra State

ABSTRACT

Potable water storage and distribution systems in Enugu urban were investigated. Potable water storage and distribution systems were first reviewed. Available potable water storage facilities and distribution networks in the city were then evaluated on the basis of their conditions, location, capacity and functions. Method of study was by visit to storage reservoirs and a study of the distribution networks. Results show that there are thirteen reinforced concrete reservoirs of capacities ranging from 2,000m^3 to 20,000m^3 and a distribution pipe networks in different parts of the city covering a distance of 200km. These reservoirs and the pipe networks are being operated by Enugu State Water Corporation. A number of households in the city use plastic tanks to store potable water which they buy from water vendors. The vendors source the drinking water from private borehole operators, unprotected springs, rivers and streams. This calls for urgent attention to save disease outbreak in the metropolis.

1.0 INTRODUCTION

1.1 Background

Water supply systems have been vital part of human life since before recorded history. Early systems involved drawing water out of a river, stream or well with a jar or bowls. This was followed by aqueducts built by ancient Egyptians to convey water to other desirable locations. In the 17th century, cast-iron piping was developed and used in Europe to convey water (Remmers, 1985). Water system technology changed drastically during the Industrial Revolution when engine and motor driven pumps were developed, concrete tanks employed to store water and modern pipes used to convey water to long distances. Also, chlorine was discovered to be an effective germ-killing agent.

Wateris a very important commodity in human life. It serves as food required by human system. It is needed for industrial production, functioning of hospitals, waste water sink, hydro power and other urban and rural activities. It is also required for irrigated agriculture, energy production, etc. (SIWI, 2003). Even though household potable water demand is small, the devil is in the details of ensuring that water is safe and getting it to the people who need it in an affordable manner (IFPRI, 2002).

The developing world especially Africa and Asia remains in the mist of water crises. They are among the billions of people around the globe who lack access to any improved water source e.g. a pipe, borehole or protected spring.

The amount of potable water available from supply source may not always be adequate to satisfy demand at a particular point in time. In this case, it is frequently necessary to hold a sufficient quantity in storage to be drawn during periods of high demand – such as in the morning and evening (Huisman, 1981). Typically, potable water is stored after all treatment and pumping processes have been completed usually at a point close to or within the distribution system and at an elevation above the highest point of discharge. This is necessary so that the stored water can continue to flow to consumers by gravity even if there is break down in the treatment or pumping plant. In addition to supplying water during periods of shortages or high demand, water storage reservoirs perform other beneficial functions such as; maintaining constant water pressure in the distribution system, alleviating the need for pumps to run continuously, and improving system reliability.

Tanks usually located at a close to or within the areas of high consumption will reduce the length of distribution pipes. Also, location of storage tanks nearest to the intake (source) will reduce a long piping main (Ritter, 1985).

Water reservoirs could be made of concrete re-inforced with internal steel to tensile strength, earthen basins with impermeable liners, steel tanks, plastic, etc.

Potable water distribution is simply the pattern in which water is transported from either the source or storage reservoir to the final consumers. In the past, this consisted of the use of a jar or bowl to move the water from the source to homes. As civilization came, cast iron pipes were used as conduits through which water is conveyed to desirable locations. Now modern pipes made of asbestos and synthetic materials have been manufactured and used for water distribution in the cities. A network of pipes is connected for water delivery. These pipes are of varying diameters depending on the volume of water to be moved. The volume of water in turn depends on demand. There are three major patterns in which the system is connected (Al-Layla and Ahmed, 1977). These are branching pattern which is similar to the branching of a tree, a grid pattern which has all the pipes interconnected with no ends – so that water circulates and then the last pattern known as grid pattern with loops developed to improve water pressure in specific areas of the city

The objectives of this study are to identify and assess potable water storage and distribution systems in Enugu urban

2.0 RESEARCH METHODOLOGY

2.1 Research Procedure

The procedures adopted in this research involved a visit to storage reservoirs operated by the state water corporation for potable water supply in the city.

The assessment includes number, size and locations of reservoirs as well as the distribution pattern and schedules by the Enugu State Water Corporation. The visit was conducted by the author between November 2008 and May 2009.

3. RESULTS AND DISCUSSION

3.1 Potable Water Storage Systems

Results from the field study shows that potable water is stored mainly in concrete, metal or plastic tanks. Metal and plastic tanks are used by homes and companies while the state water corporation makes use of reinforced concrete tanks for reservoirs.

An 18000m^3 underground tank on which a fountain is resting is shown on Figure 1. Figure 2 is a 20,000m^3 ground level reinforced concrete tank. The two tanks (Figures 1&2) are located at the foot of Milliken hill. They are owned and used by the Enugu State Water Corporation for water storage and distribution.

Table 1 presents all the tanks with the makes, levels in relation to ground and their locations. There are thirteen reservoirs at under ground and ground levels. The capacities of the reservoirs range from as low as 2000m^3 to as high as 20,000m^3. They provide such functions as water storage, water treatments, pressure break, provision of necessary head/pressure for water conveyance, etc. The reservoirs are located in Ajali and Abonuzu head works, Agbaja Ngwo, Foot of the Mliken hill, Idaw River, Thinkers corner and Iva Valley.

3.2 Potable Water Transportation and Distribution

Potable water transportation and distribution in Enugu Metropolis are of two kinds. The first is that employed by those who patronize private borehole sources. In this category, potable water transportation and distribution are done by the use of tanks on trucks. The second category is the use of suitable pipe networks to move potable water from Iva Valley and Ajali sources to desirable locations. This method is used by the Enugu State Water Corporation.

3.2.1 The Iva Valley Distribution Network

Water from the springs is transported to the sedimentation tank at Ngwo from where it further flows to the 4500m^3 underground reservoir at the foot of Milliken Hill via DN 450 ductile/steel pipe. From this the system is connected to the distribution network supplying water to GRA, Iva Valley, Iva Pottery and Secretariat Quarters. All flows are by gravity. That is, no pumping operation.

3.2.2 The Ajali Distribution Network

The distance from Ajali Head works to Abonuzu Head works is 6km. The distance from Abonuzu Head works to Enugu and Nsude is 38km and 4.8km respectively. Impounded raw water from Ajali River is lifted to Abonuzu using low lift pumps via DN 1000 pipe line. After treatment at Abonuzu, the clean water is transported at a high lift pumping to the twin break pressure tanks at Nsude via a DN 900 steel pipe-line. From Nsude, the water flows by gravity to the reservoir at Agbaja Ngwo and further to the high pressure zone ground level reservoir at Iva Valley via DN 600 steel pipe line. From this reservoir, the water flows to the 20,000m^3 ground level reservoir (Figure 2) at the foot of Milliken Hill where it is served to all parts of the metropolis except Emene. Part of the water is delivered to the ground level reservoir at Thinker's Corner via a DN 200 diameter pipe line from where Emene is served. All flows are by gravity.

Water distributions to service areas are mainly by gravity flow with asbestos cement pipes of diameters DN 50 to 600. The distribution network is about 200km.

Table 2 shows weekly water supply calendar used by the corporation. From the table, all parts of Enugu Metropolis are supposed to get water at least once a week.

4. CONCLUSIONS

*There are thirteen reinforced concrete reservoirs of the capacities between 2000m^3 to 20, 000m^3 operated by the state water agency.

***** The reservoirs perform such functions potable water storage, pressure break, provision of head pressure, etc

*There are pipe networks covering a distance of 200km parts of the city including the suburbs.

*Private homes and companies store potable water in plastic and metal tanks

REFERENCES

Al-Layla A. and Ahmed S. (1977). Water Supply Engineering Design: ANNARBOR Science Publishers Inc. Ann Abor Michigan 48104 M. N.

ENSWC, (2004). Enugu State Water Corporation. Supply. A Technical Report on Enugu State Water Supply. Enugu Nigeria.

Husman L. (1981). Low Cost Technology for Public Water Supplies in Developing Countries: International Water Supply Association. Berlin, West Germany, March 31 – April 1.

IFPRI (2002) International Food Policy Research Institute. Dying for a Drinking of Water: In the News and Views of 2020 Vision for Food, Agriculture and Environment. FUTURE HARVEST.

Remmers J. (1985). Understanding Water Supply: General Considerations: Volunteers in Technical Assistance (Vita) Manual. 1815 North Lynn Street, Arlington Virginia, USA

Rita C. M. (1985). Understanding Potable Water Storage: 1815 North Lynn Street Arlington Virginia, 22209, USA Jones, P. Reviewed.

SIWI (2003)..Stockholm International Water Institute World Water Week: First Announcement and call for Abstract



Fig, 1: A Fountain Resting on 18,000m^3 Underground Tank at the Foot of Milikin Hill, Enugu.



Fig.2: A 20,000m^3 Ground Level Concrete Tank at the Foot of Milikin Hill Enugu.

Table 1: Reservoirs for Potable Water Supply and Storage in Enugu Metropolis

S/N	Description and level	Location	Capacity (cm^3)	Function
1.	Reinforced concrete underground wet pit	Ajali head works	---	Stores impounded raw water from the river before treatment
2.	Reinforced concrete underground tank (flash mixer)	Abonuzu head works	---	First tank to receive the raw water. The chemicals are mixed with the raw water, alum, lime etc
3.	Reinforced concrete underground tanks (sedi flux)	Abonuzu head works	---	For sedimentation and fluctuation (to remove dirt from chemical).
4.	Reinforced concrete underground tank	Abonuzu head works	20,000	Stores clean water ready to be pumped out.
5.	2 ground level reinforced concrete tanks	Nsude	2,000 each	Provide pressure break from Abounuzu
6.	Reinforced concrete ground level tank	Agbaja Ngwo	10,000	Receives supplies from twin tank at Nsude.
7.	Reinforced concrete tank	Foot of Milliken Hill.	20,000	Provides terminal pressure for water distribution
8.	Reinforced concrete underground tank	Foot of Milliken Hill.	18,000	Receives water from Iva Valley springs for distribution
9.	Reinforced concrete ground level tank	Iva Valley	3,000	Provides high pressure zone for direct distribution
10.	Reinforced concrete underground tank	Foot of Milliken Hill.	4,500	Receives clean water from Iva Valley springs and feeds the terminal zone also at the foot of the hill.
11.	Ground level reinforced concrete tank	Tinkers corner, Emene	12,500	North East Pressure Zone. Provides head for water distribution in Emene area.
12.	Ground level reinforced concrete tank	Idaw River	12,500	Under the terminal pressure zone and provides pressure for water distribution.

Source: Enugu State Water Corporation, 2004.

TABLE 2: ENUGU STATE WATER CORPORATION

WEEKLY WATER SUPPLY SCHEDULE

S/N	DAYS OF THE WEEK	SUPPLY FOR AKWUKE WATER SCHEME	INDEPENDENCE LAYOUT	THROUGH THE RANGERS BOOSTER STATION	HIGH PRESSURE LINE	NORTH EAST TANK
1.	MONDAY	UGWUAJI	SECOND AVENUE	GOVT. HOUSE	SUPPLY ON SUNDAYS AND TUESDAYS FED. GOVT. COLLEGE, FED. SECRETARIAT RECTORS VILLA AND 7UP ROAD WITH GOVT. HOUSE SWIMMING POOL.	SUPPLY ON THURSDAYS AND FRIDAYS EMENE AREAS, NZA ST., EZILO AVENUE UMUOJI ST., NNOBI ST., FED. GOVT. COLLEGE AND CVUS OFFICE.
2.	TUESDAY	ARMY BARRACKS	-DO-	RANGERS AVANUE		
3.	WEDNESDAY	AMECHI AWKUNANAW	LINK ROAD AND FIRST AVENUE	WAEC		
4.	THURSDAY	-DO-	-DO-	NAWFIA/ CATHEDRAL AVENUE		
5.	FRIDAY	ARMY BARRACKS/ EBONY PAINT	LOBITTO CRESCENT AND VALLEY CRESCENT	GOVT. HOUSE		
6.	SATURDAY	-DO-	-DO-	FED. GOVT. ROAD		
7.	SUNDAY	-DO-	-DO-			

REMARKS:_____

_____

_____

_____

_____

TABLE 2 CONTD: SCHEDULE OF WATER DISTRIBUTION TO ABAKPA NIKE

MONDAY	–	NIKE ROAD, AMORJI NIKE, MONASTRY, OBINAGU ROAD
TUESDAY	–	PARTY HOUSE, NIKE LAKE
WEDNESDAY	–	OGWUAGOR PARTS I AND II, EDWARD NNAJI ROAD
THURSDAY	–	UGBENE AREA
FRIDAY	–	AMURI ROAD, DDL, MBOSI UGBOYE
SATURDAY	–	OLD HOUSING AND NEW HOUSING
SUNDAY	–	UPPER HOUSING DOWN TO GSS, ABAKPA AND COLLEGE ROAD

COMMUNITY-BASED ADAPTIVE MEASURES: IMPERATIVE FOR EFFECTIVE CLIMATE CHANGE ADAPTATION STRATEGY IN AFRICAN AGRICULTURE

Obi, O. F.[1], Ugwuishiwu, B. O.[2] and Nwakaire, J. N.[3]

Agricultural and Bioresources Engineering Department, University of Nigeria, Nsukka, Nigeria.francis.obi@unn.edu.ng; boniface.ugwuishiwu@unn.edu.ng; joel.nwakaire@unn.edu.ng

ABSTRACT

Climate change and variability is expected to hit developing countries disproportionately especially the Least Developed Countries (LDCs) because of their heavy rely on their natural resources for survival. This group of countries of which African countries are the majority, have contributed the least to the emission of greenhouse gases due to their poor state of technological development but they are most vulnerable to the effects of climate change especially the poor and marginalized communities in these countries. Although much has been done in assessing the probable impact of unabated effects of climate change in Africa in terms of describing and analyzing climatic factors to support the existence of climate change, vulnerability to climate change and identifying potential adaptation options, there remains much to be done in adopting climate change adaptive measures specific to individual rural African communities. Top-down approach has been used in most adaptation efforts and little attention has been paid to adaptation strategies specific to rural communities. The objectives of this study are to identify the critical role of rural African communities in the overall sustainability of African countries; to review the vulnerability of the rural African communities to climate change and its variability; establish the effectiveness of community-based adaptation approach in climate change adaptation, mitigation and capacity building in rural African communities; and to develop an effective approach for its implementation.

Keywords: Rural community, climate change, climate variability, adaptive measures

1.0 Introduction

The United Nations Framework Convention on Climate Change (UNFCCC) in its article 1 (UNFCCC, 1992) defines climate change as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. It refers to short, medium, and long-term changes in weather patterns and temperature that are predicted to happen, or are already happening as a result of anthropogenic emissions of greenhouse gases such as carbon dioxide (Reid et al., 2009). These changes include a higher frequency of extreme weather conditions as well as greater unpredictability and variability in the seasons of rainfall and sunshine. Climate variability on the other hand is variations in the mean state of the climate on all temporal and spatial scales beyond that of individual weather events. Overlying this increased variability are expected longer-term changes in temperature and rainfall. This variability is expected to hit developing countries disproportionately since poor people rely heavily on natural resources and agriculture for survival (Paavola and Adger, 2002).

The Intergovernmental Panel on Climate Change (IPCC, 2007a) says that climate change will lead to more extreme climatic events, compromising crops, food security, shelter, and livelihoods of the Least Developed Countries (LDCs).African countries constitute the bulk of the LDCs, which is a group of the poorest developing countries of the world (29 countries in Africa, 10 in Asia and 7 small developing Island states).This group of countries have contributed least to the emission of greenhouse gases due to their poor state of technological development but they are most vulnerable to the effects of climate change especially the poor and marginalized communities in these countries (Reid et al., 2009). In addition to that, they have the least capacity both technological and information wise to adapt to these changes. Despite the group's wide geographical spread, it is characterized by its vulnerability to climate change, due to its precarious economic situation as well as its exposure to very extreme weather conditions (Konate and Sokona, 2003).IPCC (2007b) reported that rural African communities are amongst the most vulnerable to climate change and variability.

Adaptation to climate change has become an important policy priority in the international negotiations on climate change in recent years. However, it is yet to become a major policy issue within the developing countries, especially the LDCs due to so many other national issues such as conflicts ravaging these countries. Although much has been done on assessing the probable impact of unabated effects of climate change in Africa in terms of describing and analyzing changes to support the existence of climate change, vulnerability to climate change and identifying potential adaptation options, there remains much to be done in sensitization and dissemination of climate change adaptive measures specific to individual rural African communities. Whilst rural people are very much aware of changes in their environment, they often have little knowledge of the global causes and effects of climate change. These rural communities are most hit by the effect of climate change and their roles are vital to the survival of the continent from the impact of climate change on water resources, agriculture and overall livelihood of the Africa people. Top-down approach has been used in most adaptation efforts and little attention have been paid to adaptation strategies specific to rural communities and their efforts to cope with their changing environment (Reid et al., 2009). The objectives of this study are to:

i. Identify the critical role of rural African communities in the overall mitigation and adaptation of the African continent to climate change;
ii. to review the vulnerability of the rural African communities to climate change and its variability;
iii. Establish the effectiveness of community-based adaptation approach in climate change adaptation, mitigation and capacity building in rural African communities; and
iv. To develop an effective approach for its implementation.

A study as this is justifiable given the fact that the main occupation of rural African dwellers (constituting over 60% of the total population) is agro-sylva-pastoral in nature. In Mali for example, 95% of the country's population depend on the primary sector (the agro-sector), which provides the basic raw materials required by the industrial sector and thus contributes an important part of the country's gross national product (Konate and Sokona, 2003). Thus, the impact of climate change on African agriculture is but a catalyst to a chain reaction of multiples of negative impacts that could affect every other sector of the African economy.

2.0 Why Focus On Rural African Communities?

Rural African communities are particularly vulnerable to climatic change that reduces productivity and negatively affect their weather-dependent source of livelihood - agriculture. In Malawi for example, Gandure and Alam (2006) reported that the incidence of frequent droughts and floods have left the rural populace more vulnerable to disasters such as water scarcity, food insecurity, diseases and land degradation exacerbating the poverty level of rural farmers. Some communities in Africa inhabited by rural farmers are facing diminishing limited resources (Rijsberman, 2006, and Phiri et al., 2005). Climate change and an increasing population contribute to water scarcity and limit its availability for irrigation (Turner, 2006) and other agricultural purposes. Albeit the abundance of opportunities for large scale water resource management strategies in rural communities, there have been inadequate investments, mainly due to misplaced government priorities, declining external support, poor marketing infrastructure, and non-conducive policy and institutional frameworks for its adoption (Ngigi, 2009).

Emerging evidence shows that rural women will experience even greater impact on their lives through the effects of climate change. Young (2008) reported that women are made vulnerable by their reduced access to sources of information on climate change, as well as their lack involvement in developing adaptation strategies. The impact of climate change affects everyday life and opportunities of women since in many low income countries like African countries, women already work more hours each day than men producing 60 – 80% of the food grown (FAO, 2001). As Young (2008) stated "as communities cope with the effects of changes in climate, demands on women's time and workloads are likely to increase". "The added stresses incurred by a changing climate, compound the many risks already faced by women in developing countries" (Ngigi, 2009). It is true that African rural communities have no choice but to adapt to climate change and that adaptation strategies exist. But the question is how effective are the existing climate change adaptation strategies to the needs and priorities of rural African people?

2.1 Vulnerability of rural African communities to climate change

It is unfortunate that most African countries are located in geographically vulnerable areas such as the flood-prone Mozambique or drought-prone Sudan, and in more vulnerable locations (Reid et al, 2009). In addition to this, rural African community settlements surrounding many developing countries' cities are usually cited on land prone to natural disasters such as flooding, land slide, etc. Developed nations can afford to situate themselves on safer land and can develop even disaster prone areas to withstand foreseeable risks when they occur. The rising population in African countries has resulted in high competition for food and basic resources by the teeming population. The effect of climate change on agriculture, energy, water resources, etc. has exacerbated this competition for the limited natural resources.

Rural African communities are mainly agrarian with agriculture being the main source of livelihood of the people. The over dependent of many African countries on the natural resources produced by peasant rural agricultural workers has made the impact of climatic change on agriculture felt at the national level. Agriculture is now becoming a lot more complex and riskier with a lot of unpredictable variables vital to the success of agricultural activities. Such variables include unpredictability in the timing of rainy seasons and the pattern of rain within seasons, making it difficult to decide when to cultivate, sow, and harvest. All this culminate to the need for more resources to seize the right time for carrying out agricultural activities both in the rainy and dry seasons (Reid et al., 2009). The problems that climate change appears to be exacerbating all

interact with the pressures on land, soils, and water resources that would exist regardless of climate change considering population increase in African communities (Jennings and McGrath, 2009). In addition to that, most subsistence farmers lack access to useful and comprehensible information about new scientific knowledge about climate change, as well as adaptive measures developed that could help reduce the negative impacts (Suarez et al., 2008).

Socio-economic and political dimensions influence how climate change affect different groups. African countries known for unstable government and poor implementation of people oriented policies have made her teeming population extremely vulnerable to the effect of climate change. Rural farmers for example do not have the resources to cover their losses neither has the agricultural sector grown to warrant insurance to cover loss of produce in case of storm or flood. These farmers cannot afford basic healthcare need in case of climate change induced disease outbreak which inevitably keeps them from work, affecting the overall agricultural production. Such a scenario produces a chain reaction with devastating effect on the population. According to FAO (2007), agricultural production and the biophysical, political and social systems that determine food security in Africa are expected to be placed under considerable additional stress by climate change. Climate change also has psychological and cultural effects, such as beliefs and traditions associated with the seasons being undermined by climate change (Jenning and McCrath, 2009).

2.2 Climate change variability and vulnerability: A case study of Mali

In the study of Mali's vulnerability to climate change conducted within the implementation framework of the UNFCCC and focusing on water resources and agricultural sectors, Konate and Sokona, (2003) evaluated eventual consequences of climate change on yields of millet and sorghum as well as the socio-economic impact of climate change. The average rainfall is consistently less than it was during the period of 1961-1990 causing fluctuations in the duration of the vegetation season which in turn leads to unsustainable agricultural production and degradation of the soil and vegetation. The authors reported that the annual average variation in cultivated land was 30,000 ha and if there is no climate change, there would be no structural shortages of food in the area.

2.2.1 Vulnerability of the agricultural sector in Mali

In the study by Konate and Sokona, (2003), 6 Global Climate Models (GCM) were used to establish the possible climate scenarios, which were derived from reaction equilibrium experiments. The models include the:

- Canadian Climate Change Model (CCCM);
- United Kingdom Meteorological Office (UKMO);
- United Kingdom Meteorological Office for 1989 (UK89);
- Geophysical Fluid Dynamics Laboratory Model (GFDL);
- Goddard Institute for Space Studies Model (GISS) and;
- Geophysical fluid Dynamics (Gfd3)

In addition to the GCMs, two Crop Growth simulation models were used in order to assess the impact of climate change. These were the MAIN model developed in collaboration with the Center for Agro-biological Research in the Netherlands and the DSSAT model (Decision Support System for Agro technology Transfer), which uses simplified functions to forecast crop growth, under the influence of certain factors which affect their yield. The synthesis of the results obtained revealed that by the year 2025, the average temperature rise will vary between 2.71 and

4.51°C; while the decrease in rainfall and insulation will range between 8 and 10% and 1and 10% respectively. The impact of these on crops such as sorghum was summarized as follows:

a. 16% decrease in yield for the Tiémantié variety, (for a temperature rise of 4%); which will be equivalent to food shortage affecting 12% of the region's population;
b. 26% decrease in yield for the CSM388 variety, which is equivalent to the food ration of 44% of the region's population.

2.2.2 Vulnerability of the water resource sector in Mali

Two possible climate scenarios were arrived at using analogue method in addition to expert judgment and simulation models. The climate scenarios were:

a. a continuation of the present trend, which, by the year 2025 will culminate in a temperature rise of 0.4 to 1.1°C and a decrease in rainfall of between 12 and 29%.
b. a doubling of the CO_2 concentration, resulting in a 15% increase in rainfall in the year 2025.

Mali's vulnerability to climate change is but a glimpse of the vulnerability of other African countries in the area of crop production, animal production, water resource management, energy resources and the overall livelihood of rural dwellers who in their peasant ventures contribute immensely to the overall gross domestic product of their countries. Generally for the African continent, it is expected, according to relevant studies (Hulme et al., 2001; IPCC, 2007c; Dinar et al., 2008; Reid et al., 2009), that unabated climate change effects would result to the following:

a. By 2020, between 75 million and 250 million people are projected to be exposed to increased water stress due to climate change. In addition to that, an increased demand due to population increase is expected which will adversely affect livelihoods and exacerbate water-related problems.
b. Agricultural production, including access to food, in many African countries and regions is projected to be severely compromised by climate variability and change. The area suitable for agriculture, the length of growing seasons and yield potential, particularly along the margins of semi-arid and arid areas, are expected to decrease. This would further adversely affect food security and exacerbate malnutrition in the continent. In some countries, yields from rain-fed agriculture could be reduced by up to 50% by 2020.
c. Local food supplies are projected to be negatively affected by decreasing fisheries resources in large lakes due to rising water temperatures, which may be exacerbated by continued overfishing.
d. Towards the end of the 21stcentury, projected sea level rise will affect low-lying coastal areas with large populations. The cost of adaptation could amount to at least 5-10% of Gross Domestic Product (GDP). Mangroves and coral reefs are projected to be further degraded, with additional consequences for fisheries and tourism.
e. The adverse impacts of temperature rise, of approximately 0.5^{o}C per century on agriculture sector will exacerbate the incidence of rural poverty.

3.0 Community-Based Adaptation Approach

Community-based adaptation to climate change is a community-led process, based on communities' priorities, needs, knowledge, and capacities, which empowers people to plan for and cope with the impacts of climate change (Reid et al., 2009). Researchers have used expert-led solutions, such as improved climatic modeling and forecasting, which are most useful for determining large-scale mean temperatures over relatively uniform geographies (Sherwood and

Bentley, 2009). But these solutions are of little help to farmers who are more interested in local, short-term predictions, especially of rainfall of which rural people are often at least as accurate as meteorologists (Orlove et al., 2002). Community-based adaptive measures attempt to factor in the potential impact of climate change on livelihoods specific to the people and their vulnerability to disasters by using local and scientific climate change knowledge.

Implementing an approach as such may start by identifying communities in poor countries that are most vulnerable to climate change, or these communities may themselves ask for assistance (Kelman et al., 2009). Followed up with a strategy that entails the involvement of communities in intensive, locally led learning-action on climate change and resilience, including local content process design, curriculum development for such training taking into cognizance the need and priorities of the rural community, and subsequently followed-up with visits to document learning and innovations (Figure 1). It identifies the vulnerability of individual communities to climate change and its variability, synthesizes adaptation practices peculiar to the community that could catalyze long-term adaptation processes. The major steps include:

i) identification of community's vulnerability to climate change based on natural, cultural and socio-economic conditions;
ii) participatory deliberation on the needs and priorities of the people;
iii) collation of existing rural adaptation measures based on the needs and priorities of the people;
iv) synthesis of new and existing potentially suitable adaption options for the rural community:
v) on field participatory evaluation of adaption strategies;
vi) identification of successful adaptation strategies and;
vii) field demonstration to rural people.

Community-based adaptation approach to climate change gives an indication of risk communities and which groups are most vulnerable. It also helps communities assess what capacities they have for reducing vulnerability, and aim to empower communities to take action themselves to reduce the risks they face (Reid et al, 2009).

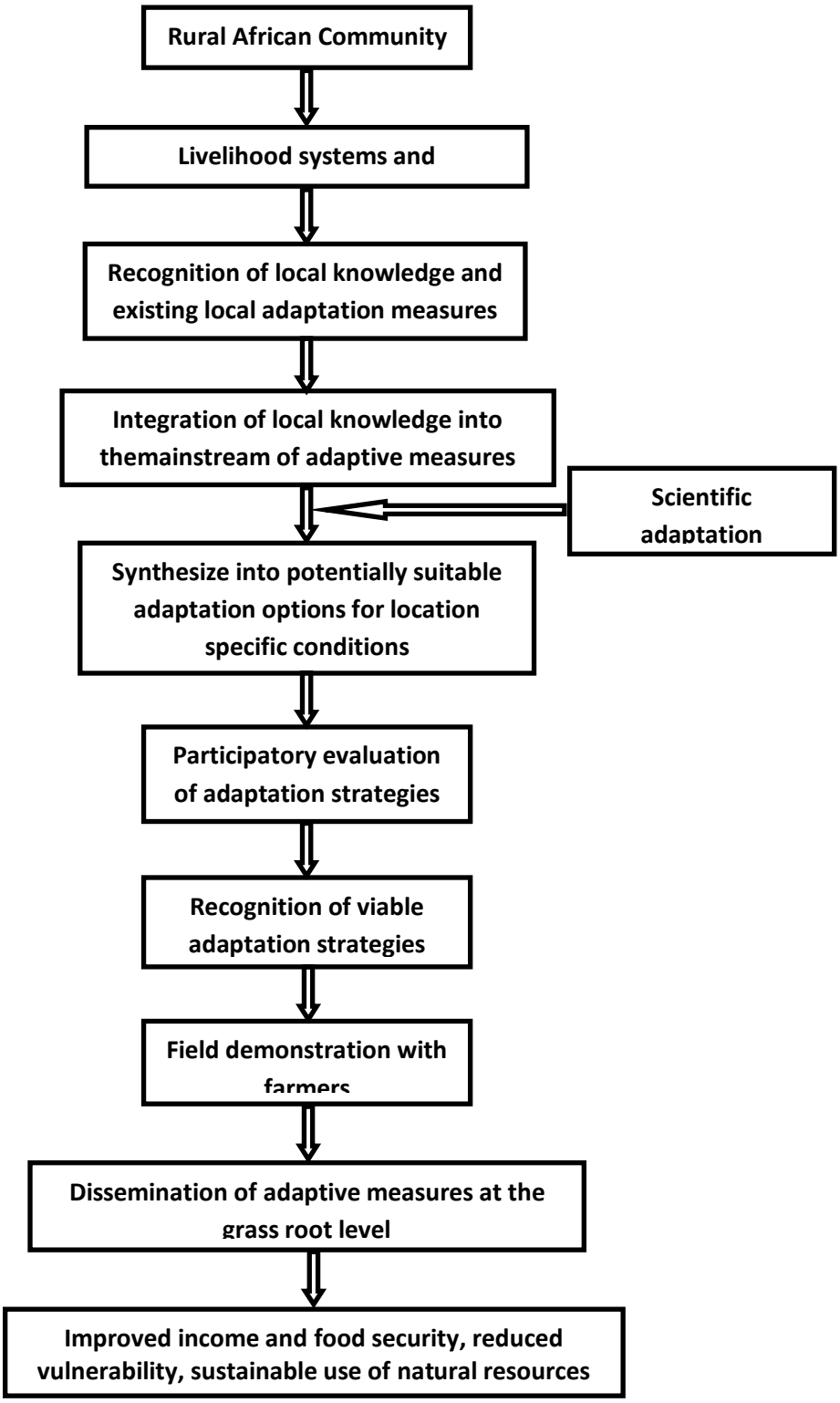


Figure 1: Sequential approach to implementing a community-based adaptive measure

3.1 The "Katalysis" approach

A typical community-based adaptation approach is the "Katalysis" approach – an experimental learning-action approach to climate change adaptation. This strategy was piloted by Sherwood

and Bentley (2009) in two highland locations in Bolivia and Ecuador, the poorest regions of the Andes. According to the authors, "Katalysis" builds on 'discovery learning' tradition of farmers in the field, in which farmers share their experience, strengthen their ecological literacy through learning experiments, and identify ways of improving agriculture through group problem-solving. It focuses on enhancing local knowledge of climate change and creating opportunities developed by the rural people for coping with it. Furthermore, it employs the experience and priorities of the rural people at individual level and develops to the community level through problem-solving and priority interests. "Katalysis" involves a self-directed learning approach to the effect of climate change and adaptation strategies.

3.2 Success elements of community-based adaptation strategies

Many literatures (Bunch, 1982, Holt-Gimenez, 2006, van den Berg and Jiggins, 2007, Schut and Sherwood, 2007, Sherwood and Bentley, 2009, Bizikova et al., 2009) agree that developing a bottom-up approach to climate change adaptation works and is effective. "A bottom-up approach assess the vulnerability and adaptive capacity to current climate variations and future climate trends at the local level….they draw primarily on local knowledge and can more effectively target the poorest and most vulnerable in developing appropriate adaptation responses" (Mitchell and Tanner, 2006). This approach is effective because of the following reasons:

a. It taps into time-tested approaches already in use by the rural farmers.
b. It adds value to the lives of the rural people by making them a part of a change which will be sustained by the people themselves.
c. It helps address gender issues as farm families are involved in such approach and not individuals.
d. It gives the farm families opportunities to contribute in the design of the training curriculum as well as the planning and implementation.
e. It creates an avenue for transfer of knowledge specific to the rural people.
f. It gives quick, tangible successes which are the primary source of motivation for long-term goals.
g. It starts simple and diversifies helping rural people follow through the adaptation process.

4.0 Adaptative Measures Specific To Rural African Communities

4.1 Provision of technical knowledge

Providing rural communities with the technical knowledge they need through cultural leaders, agricultural decision makers and rural technical service groups to enable them to plan and manage their agricultural activities more efficiently is a key strategy for cushioning climate change effects. This can be achieved by keeping rural communities informed about the state and evolutionary effect of climate change on agro-pastoral fields by means of follow-up of relevant indicators - meteorological and hydrological indicators, etc., their impacts on crops, pastures and water resources, and climate change adaptation strategies. It is important that agricultural workers, community media services (radio, television or print), extension workers as well as workers from hydrological department be involved in the collation, analysis and interpretation of data collected from rural agricultural workers, meteorological and hydrological stations on farming, lands, and rainfall. The information synthesized could be prepared in the form of Newsletter written in the local dialect and distributed through the rural leader or passed on to the community through town criers or any other effective means specific to the rural community. This would arm rural communities with up-to-date information on the level of the impact of

climate change on agriculture specific to their communities as well as new technologies of climate change adaptation.

4.2 Active participation of rural agricultural workers

Rural dwellers are not very likely to accept information on any issue which they do not understand nor have a grip of. Most of the of the effects of climate change have a cultural meaning to rural African communities and such belief could only be broken by getting them involved in activities related to climate change. The sensitization of rural communities, by getting them to be directly involved in the various activities on climate change effects and adaptation, through teamwork and a chain reaction network, involving extension workers, agricultural officials and policy makers would help emphasize the importance of considering meteorological information in all agricultural decision making processes, so as to minimize climatic risks and safeguard or even increase agricultural production (Konate and Sokona, 2003).

4.3 Participatory development of adaptation strategies

The provision of professional training for rural agricultural workers and their introduction to data collection and the practical use of meteorological and agro-meteorological information, in all agricultural decision making processes would help in the development of endogenous technologies for climate change adaptation. There is need to establish a functional system for the compilation and dissemination of climate change information and advice to rural agricultural workers as regards to agro-meteorological information and land use. Such would help farmers in the use of agro-climatic data for planning agricultural activities and in determining the most appropriate time to begin the planting season.

4.4 Development of endogenous water resource management

Endogenous water resource management strategies would take into account the physical conditions of the terrain of the community and the economic implication of the management system with regard to the rural dwellers. Effective rural water management strategies include:

- Development of rural community water supply through the construction of wells equipped with hand or leg operated pumps;
- Development of surface water supply system from nearby rivers and streams to farms and to livestock through the creation of contours serving as water channels and;
- Construction of small dams and drains to retain water flows during periods of excessive rainfall later to be used for agricultural purpose;
- Exploring the holding capacity of Soil Organic Matter (SOM) which is a less expensive alternative to storing water by incorporating crop residues, applying manure, reducing tillage, suing cover crops, dead and live barriers, and conservation ditches.

4.5 Development of drought resistant crop varieties

Breeding generally drought-tolerant crop varieties is important but not enough in mitigating the effect of climate change on the lives of rural African communities. As de Haan (2009) rightly pointed out drought-tolerant varieties may be important but not in all regions. He further added that in the Andes, for example, traditional crops and potato varieties are their preferred crops and that maintaining the varieties that farmers have and love may be as important as breeding new ones. It is strongly suggested that farmers should shape the research agenda according to local

priorities, and that smallholders and researchers should learn together (Sherwood and Bentley, 2009). Drought-resistant crop varieties as well as livestock should be developed with focus on the need of rural communities and not on what is perceived as important to the general populace.

4.6 Use of participatory video to promote climate change adaptation

The use films produced by the villagers with a local perspective, language, and approach could be an effective way of disseminating community-based adaptation. The films, usually short with its content being on climate change adaptation strategies peculiar to the rural community. Highly placed farmers respected by the people could be used as reporters on climate change issues and farmers could freely express their knowledge, directing and filming absolutely everything according to their own perspectives (Baumhardt et al., 2009). This method has been applied in Malawi rural communities with successful results (Baumhardt et al., 2009). The content of the films produced by the rural people of Mphunga village, in Malawi were specific to the vulnerability and need of the people. The films were on crop diversification to ensure food production even with little rainfall, irrigation farming to increase production, rearing of chicken vs. ducks as ducks can survive in the face of flooding while chicken get drowned due to their inability to swim, the use of storm drain and elephant grasses to reduce surface runoff, new methods of storing food produce and food alert methods to awaken the communities to impending disaster. Participatory video is a suitable tool for developing and transferring community-based knowledge on climate change adaptive measures among vulnerable communities (Lunch and Lunch, 2006).

5.0 Benefits Of Community Based Adaptive Measures

Community-based adaptation draws on participatory approaches and methods developed in community development work as well as sectoral-specific approaches such as farmer participatory research which help communities learn to analyze the causes and effects of climate change, to integrate scientific and community knowledge of climate change, and to develop and implement endogenous adaptation measures (Reid et al., 2009).The adoption of climate change adaptation strategies specific to rural African communities as demonstrated in Mali showed a production increase by an average of 42% for millet, 35% for sorghum and 68% for maize (Konate and Sokona, 2003). It was further reported that the use of calendars showing seed planting times, resulted in a significant reduction in seed planting failure, which decreased from 40% to 5%, representing a significant decrease in seed loss. These impacts inevitably manifested in the economic life of the rural dwellers such that the cost/benefice ratio of the agro-meteorological assistance operations in rural areas was found to be 1/21 (Konate and Sokona, 2003).

Besides the economic impact of such strategies, social and environmental impacts are also expected. Such impacts are revealed in the development of technical knowledge of rural communities, sustainable and cohesive team work between rural farmers and national policy makers on climate change, effective application of labour for agricultural activities minimizing loss of time, energy and resources, and better conservation and use of agricultural land. Furthermore, identification and effective use of water shortage and high temperature resistant varieties for planting, improved agricultural and water harvesting techniques that maximize the use of available water resources for agricultural activities are also imminent from the implementation of climate change adaptation strategies specific to rural African communities.

6.0 Conclusions

The importance of developing climate adaptation strategies specific to individual rural African community cannot be over emphasized. We know that farmers often miss opportunities for improving their livelihood because of knowledge gaps or solutions that do not meet their needs or priorities. Rural community-based adaptation strategies would help rural people bridge those gaps so that they may creatively manage their own resources in response to the growing threat of climate change. This flexible knowledge-base approach for improving agriculture would enhance the environmental resilience of rural farms and production systems through targeted learning and action on the use of local resources (e.g. cover crops), appreciation of local knowledge and creative adaptations, complemented by experiments with scientific, but accessible, adaptation strategies.

References

Baumhardt, F., Lasage, R., Suarez, P. and Chadza, C. (2009). Farmers become filmmakers: climate change adaptation in Malawi. Participatory Learning and Action (PLA) 60. International Institute for Environment and Development.

Bentley, J.W. (1989). What farmers don't know can't help them: the strengths and weaknesses of indigenous technical knowledge in Honduras. Agriculture and Human Values 6(3), pp. 25-31.

Bizikova, L., Dickinson, T. and Pinter, L. (2009). Participatory scenario development for climate change adaptation. Participatory Learning and Action (PLA) 60. International Institute for Environment and Development.

Bunch, R. (1982). Two ears of corn: A guide to people-centred agricultural development. World Neighbors: Oklahoma City, OK.

De Haan, S. (2009). Potato Diversity at Height: multiple dimensions of farmer-driven in-situ conservation in the Andes. PhD dissertation, Wageningen University: The Netherlands.

Dinar, A., Hassan, R., Mendelsohn, R. and Benhin, J. (2008). Climate change and agriculture in Africa: Impact assessment and adaptation strategies. Earthscan, London.

FAO. (2001). Global Farming Systems Study: Challenges and Priorities to 2030. FAO, Rome, Italy.

FAO (2007). Climate change and food security: A framework for action. Report by an Interdepartmental Working Group on Climate Change. FAO, Rome, Italy.

Gandure, S. and Alam, K. (2006). Climate change and smallholder farmers in Malawi: Understanding poor people's experiences in climate change adaptation. A report by Action-Aid, Action-Aid International.

Holt-Gimenez (2006). Campesino a Campesino: Voices from Latin America's farmer-to-farmer movement for sustainable agriculture. Food First Books: Oakland, CA.

Hulme, M., Doherty, R., Ngara, T., New, M. and Lister, D. (2001). African climate change: 1900-2100. Climate Research, 17:145-168.

Huq, S., Reid, H and Murray, L. (2003). Mainstreaming adaptation to climate change in least developed countries (LDCs). Working Paper 1: Country by Country Vulnerability to Climate Change. International Institute for Development and Environment.

IPCC (2007a). 'Climate Change 2007: Impacts, Adaptation and Vulnerability.' Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

IPCC (2007b). 'Climate Change 2007: Synthesis Report.' Contribution of Working Groups I, II, and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

IPCC (2007c). IPCC 4th Assessment Report 2007. Intergovernmental Panel on Climate Change. <www.ipcc.ch> Accessed on 11/11/11.

Jennings, S. and McGrath, J. (2009). What Happened to the Seasons? Oxfam GB Research Report: United Kingdom.

Konante, M. and Sokona, Y. (2003). Mainstreaming adaptation to climate change in Least Developing Countries (LDCs). Working Paper 3: Mali country case study. International Institute for Environment and Development. Shell Foundation- Sustainable Energy Programme.

Kelman, I., Mercer, J. and West, J. J. (2009). Combining different knowledge's: community-based climate change adaptation in small Island developing states. Participatory Learning and Action (PLA) 60. International Institute for Environment and Development.

Lunch, N. and Lunch, C. (2006). Insights into participatory video: A handbook for the field. Insight: Oxford.

Mitchell, T. and Tanner, T. (2006). Adapting to climate change: Challenges and opportunities for the development communities. Institute of Development Studies. Tearfund.

Ngigi, S.N. (2009). Climate change adaptation strategies: Water resources management options for smallholder farming systems in Sub-Saharan Africa. The MDG Centre for East and Southern Africa, The Earth Institute at Columbia University, New York. 189 pp.

Orlove, B. S., John C. H. Chiang and Mark A. Cane (2002). Ethno climatology in the Andes. American Scientist, 90:428-435.

Paavola, J. and N. Adger (2002). Justice and adaptation to climate change. Tyndall Centre for Climate Change Research, Working Paper 23.

Phiri, M. G., Saka, I. and Alex, R. (2005). The impact of changing environmental conditions on vulnerable communities of the Shire valley, southern Malawi. Lilongwe, Malawi.

Reid, H., Alam, M., Berger, R., Cannon, T., Huq, S., and Milligan, A. (2009). Community based adaptation to climate change: An overview. Participatory Learning and Action (PLA) 60. International Institute for Environment and Development.

Rijsberman, F. R. (2006). Water Scarcity: Fact or Fiction? AWM, 80: 5–22.

Sherwood, S. and Bentley, J. (2009). Katalysis: Helping Andean farmers adapt to climate change. Participatory Learning and Action (PLA) 60. International Institute for Environment and Development.

Schut, M. and Sherwood, S. (2007). FFS in translation: scaling up in name, but not in meaning. LEISA Magazine on Low External Input and Sustainable Agriculture, December, 24(4): 28-29.

Turner, N. C. (2006). Water Scarcity: Challenges and Opportunities for Crop Science. AWM, Special Issue 80: 1 – 3.

UNFCCC (1992). United Nations Framework Convention on Climate Change. FCCC/INFORMAL/84 GE.05-62220 (E) 200705.

Van den Berg, H. and Jiggins, J. (2007). Investing in farmers: the impacts of Farmer Field Schools in relation to IPM.' World Development, 35(4): 663-686.

Young, M. H. (2008). Global climate change: What does it mean for the world's women? Population Action International (PAI) <www.populationaction.org/.../global-climate-change-what-doe.html> Accessed on 11/11/11.

EVALUATION OF SOIL AND WATER QUALITY OF WATARI IRRIGATION PROJECT IN SEMI-ARID REGION, KANO, NIGERIA

N.J. Shanono[1] M.K. Othman [2], N.M. Nasidi[1] and H. Isma'il[3]

[1] Department of Agric. Eng., Bayero University, Kano, Nigeria
[2]NAERLS, Ahamadu Bello University, Zaria, Nigeria
[3]Department Agric. Eng., Ahmadu Bello University, Zaria
njshanono06@yahoo.com

ABSTRACT

Soil and water samples were collected during the irrigation period of April, 2007. The samples were taken at three places (Upstream, midstream and downstream) of each of the four sectors of the Project at the depths of 1-15cm and 15-30cm below the surface. Water samples were taken from the storage (Dam), main canal, distributaries canals, field drains and collector drains of sector I, II, III, IV and at the main collector drain. All the samples (Soil and Water) were analysed for their chemical constituents to evaluate their quality for irrigation purposes. It was found that, the chemical compositions of the soil were still within acceptable limits (pH range 4.56 – 6.89, EC range 0.18 – 3.21 ds/m, ESP range 5.00 – 11.00%, and SAR range 0.31 – 0.68). The irrigation water (pH range 6.87 – 7.40, EC range 0.05 – 0.76 ds/m, ESP range 7.00 – 11.00% and SAR range 0.63 – 0.95) is exceptional quality and can be used for irrigation of most crops on most soil with little or no likelihood of salinity development, except on low permeable soils or soil, with restricted drainage. The main drain water (pH = 6.43, EC = 1.85ds/m, ESP = 10.00% and SAR = 0.64) shows that it can be recycled for irrigation purposes especially in the Semi – arid region of northern Nigeria where water is the major limiting factor for crops production.

1.0 Introduction

The importance of irrigation in the world today cannot be overemphasised. That, "The pressure of survival and the need for additional food supplies are necessitating a rapid expansion of irrigation throughout the world" (Ghuhati, 1964). Even though, irrigation is a top priority in the arid region of the world, it is also becoming increasingly important in humid region. Arid and Semi – Arid regions are areas with limited rainfall and crops are produced mostly once in a year with sometimes crops failure because of inadequate precipitation to meet crops water requirement. Crops production through Irrigation in arid regions is a necessity to meet food requirements of the ever increasing population in such regions.

In the Sudan to Sahel Savannah regions of Nigeria are located in semi – arid region with annual rainfall of less than 1000 mm. The land cultivation is traditionally once in a year due to the short duration rainy season, which lasts 4 – 5 months only. The need to feed and improve the standard of living of the ever-increasing human population led to the introduction of the irrigation schemes by Nigerian governments in the last 20 years. This has facilitated the cultivation of the same land twice or more in a year and has improved the famers' standard of living. The development of irrigation is also brought about changes in the existing natural ecosystem including the soil. The development of secondary salt-affected soils is one of such changes, which have been attributed to irrigation (Singh and Maurya, 1979). The presence of salts can drastically alter the physical, Chemical and biological properties of soil and impair its productivity (Brandy and Weil, 1999). Under saline condition nutrient toxicity and imbalance and increased osmotic potential are

common problems to plants (Berntein, 1974). Evaluation of soil and water quality of irrigation scheme helps to monitor rate of salt build up so that necessary management practice can be put in place as a control measure. Watari Irrigation project was one of the public irrigation schemes developed by Kano State government aimed at increasing crops production and livelihood of rural farmers. The project was established more than 20 years ago and there is need to evaluate the quality of soil and water in the project for possible recycling of the water to improve its efficiency and take necessary measures to protect the environment.

MATERIALS AND METHODS

The Study Area

Watari irrigation project (WIP) is located in Bagwai Local Government area, Kano State, Nigeria. The project is situated at Latitude of 12.2^0N and Latitude 8.3^0E in the valley of watari River, which is a tributary of Challawa River. The Watari irrigation project has potential irrigation area of 4,575ha out of which 2,601ha have been developed. The developed area is intersected by eight tributaries, which created major obstacles for the construction of the irrigation main canal. Therefore, the main canal was crossed over the tributaries through inverted siphons. Surface irrigation is practiced in the developed area through gravity system. The main canal is 12 km long with secondary canals branching out to convey water to four sectors (sector I, II, III and IV). A sector is an irrigation unit area that received water supply by one canal (Distributary). The metrological data obtained from the area indicated an average relative humidity of 33.5% during the dry season, and 74.5% for the wet season. And average minimum temperature of 14^0C and an average maximum temperature of 38.2^0C. It also has a monthly average precipitation of 66.5mm during the worm-wet season per month (Karaye, 2002).

Field works

Reconnaissance survey of the area was conducted in order to select soil and water sampling points. Soil and water samples were taken from different places. Soils were sampled at upstream, midstream and downstream sectors, at 1-15cm and 15-30cm (sector I, II and IV) making a total of 18 soil samples using soil auger. The water samples were taken at main storage reservoir (dam), main canal at three stations (upstream, midstream and downstream), distributaries canals, field drains of sector I, II, III and IV and at main collector drain giving a total of 17 water samples.

Laboratory works

Soil samples

The soil samples was left to dry under room condition for three days, the soil samples were then crushed and sieved through a 2mm square grid for testing chemical properties. pH of the soil sample was read directly using H19024 microcomputer pH meter (1:1 soil to water ratio); EC was also read directly using H18733 EC bridge meter (1:2.5 soil to water ratio); Ca^{2+} and Mg^{2+} by titration method of determining CEC; Na^{+} and K^{+} by absorption spectrophotometer; Al^{3+} and H^{+} by titration method of determining of EFFECTIVE CEC and SAR and ESP were calculated using expressions developed by Donahue et al. (1990) and Brandy and Weil (1999).

$$SAR = \frac{Na^{+}}{\sqrt{\frac{1}{2}[(Ca]^{2+} + Mg^{2+})}} \quad (1)$$

$$ESP = \frac{Exchangeable\ Na+,\ \ cmol\ c\ kg-1}{Catio\ exchange\ capacity,\ \ cmol\ c\ kg-1} \text{ x } 100\% \quad (2)$$

Irrigation and drainage water samples

The pH and EC of the water samples were also measured directly using pH and EC meters, respectively. Ca^{2+} and $Mg^{2+,}$ were determined using absorption spectrophotometer. With the determinations of Ca^{2+} and $Mg^{2+,}$ CEC, Na^{+} and K^{+} , SAR and ESP were calculated using equations 1 and 2.

RESULTS AND DISCUSSION

Irrigated Soil Quality

Table 1 (Appendix A) presents the chemical composition of the soil samples. The pH result shows that the soil was more saline at downstream sector with a value of 4.56 indicating acidity. The EC of the soil of all the sectors were found to be within the acceptable values (<4 ds/m) compared with soil quality standard given by Bernstain (1974) on salinity level. The ESP values were generally low, as low as 5%, the maximum value of ESP was found to be 11%. This was from a sample collected in sector III, which could be attributed to the heavy texture soils, which has affinity to sodium ions. The values of ESP in the whole area were below the threshold value of 15% that could initiate considerable particle dispersion and cause stunted crop growth (Shainberg, 1974). This could be attributed to the fact that sandy soil dominates the texture of the soil with high hydraulic conductivity for leaching down salts beyond the root zone by irrigation water or during raining season.

Irrigation Water Quality

Table 2 (Appendix B) presents the results of chemical properties of the irrigation water, the results show that the water obtained from the dam and main canal met all aspects of water quality standard as reported by Paliwal (1972), Richards (1954) and Shainberg (1978). The level of the salinity indicated by the EC, showed that the water could be classified in the upper class. Thus, the water can be used for irrigation of most crops on most soils with little or no likelihood of salinity development, except on low permeable soils or soil with restricted drainage. (C1: low-salinity-water). The results shows further that the water in the storage and the main canal, with respect to soluble salts, were of high quality and that if any salinity development is experienced in the area it has to be due to poor drainage or soil compaction in future. The storage and canal waters could also be considered to have low alkalinity level as indicated by SAR, "termed low-sodium-water". Hence it can be used continuously for irrigation purposes without a threat of sodium toxicity due to high ESP in the soil. The pH of the storage and main canal water were generally within the normal range (6.5 – 8.5) of irrigation water above and below which may indicates acidity or basicity

Considering the results obtained for distributaries canals of sector I, II, III and IV, as shown in Table 2 (Appendix B). The salinity value of EC was found to be of low level. Hence, it can be used to irrigate most tropical crops with no threat of salinity build-up. Furthermore, the water in the distributaries was found to be of low alkalinity level. Hence, it can be used continuously for irrigation with no threat of alkalinity development in the soil. Similarly, the pH status indicated the neutrality of the water in the distributaries and found to be suitable for irrigation. The result of the analysis of field drains and collector drains water of sector I, II, III and IV as well as that of main collector drain is presented in Table 2. The salinity status were found to be of low-levels while some were found to be at medium-level which can be re-used for irrigation with adequate leaching.

CONCLUSION

The study to evaluate the extent of soil and water quality levels at the Watari irrigation project was conducted. It was the first time such quality evaluation was done in the irrigation project more than 20 years after project commencement. Soil and water samples were taken at different locations and depths, which were subjected to laboratory analysis using standard procedures. The various quality indicators such as level of alkalinity and salinity and other chemical properties were used for the samples classifications. Base on the results obtained and the discussion given, the following conclusions are drawn; the irrigation water at Watari irrigation project, having satisfied all the required quality needed is of exceptionally good quality with respect to all aspects of water quality criteria for irrigation. The field and the collector drains water can both be reused (recycled) for irrigation with normal leaching with no threat for salt build –up. Soil salinity and alkalinity levels were found to be relatively low, but the rate of development can only be determined after next evaluation in the next 2 – 3 years time. However, there was potential for the development of sodium salt in sector III, which could cause alkalinity. The sector has heavy textured soil. Soil structural improvement using organic manure is recommended to enhance soil porosity for effective leaching.

REFERENCES

Brandy, N.C. and Weil, R.R. (1999). The nature and properties of soil. 12th edition. Prentice hall inc. New jersey. 118-169pp.

Bernstein, L. (1974). Crop growth and salinity in drainage for Agriculture. (J.V. Schilfgaard, e.d.) American Soc. Of Agron. Madison, Wisconsin: 33-35

Maurya, P.R. (1982). Development of Salinity and Alkalinity in irrigated soil of Nigeria. Proc. 4th Afro-Asia. Paper presented at regional conf. of ICID. Lagos, Nigeria, II; 1-1.

Mudiare, O.J. and A.D. Mohammed, (1978), Determination of Changes in Soil and Water Quality at the Kadawa Sector of the Kano River Irrigation Project Department of Agricultural Engineering, A.B.U Zaria. Journal vol.3 ISSN 1495-61 21June 2002.

Richards L. A. (1973). Diagnosis and improvement of saline and alkali soils. U.S. Dept. of Agriculture Handbook 60

Scainberg, I. and Oster, J.D. (1978). Quality of irrigation water report. Int. Information center. Paper No. 2

Singh, A., and P.R. Maurya, (1979). Salinity Status and Water Logging in Irrigated Agriculture of Northern Nigeria. Journal of 6th Nigerian National Irrigation Seminar pro. 1.

APPENDIX A

Table 1: Chemical composition of soil sampled at Sector **I, III** and **IV.** Sampling date: 12/04/2007

Effective CEC (meq/100g of soil)							Place	Depth (cm)	pH	EC (ds/m)
$Ca^{2+}+Mg^{2+}$	Na^{+}	K^{+}	Al^{3+}	H^{+}	ESP (%)	SAR				
							Sector I			
							Up-stream	1-15	6.89	0.93
								15-30	6.15	0.83
							Mid-stream	1-15	5.04	2.83
								15-30	5.32	1.24
							Down-stream	1-15	5.24	1.52
								15-30	4.56	2.40
							Sector III			
							Up-stream	1-15	5.04	0.47
								15-30	5.13	0.26
							Mid-stream	1-15	5.58	0.21
								15-30	4.80	0.25
							Down-stream	1-15	4.94	3.21
								15-30	6.78	2.46
							Sector IV			
							Up-stream	1-15	6.25	0.58
								15-30	5.98	0.31
							Mid-stream	1-15	5.35	0.28
								15-30	5.20	0.18
							Down-stream	1-15	6.27	1.54
								15-30	4.78	1.08

17.50	1.35	0.73	0.80	1.20	6.00	0.46				
18.50	1.48	0.82	0.90	1.00	7.00	0.49				
18.25	0.91	0.16	0.50	0.60	5.00	0.30				
20.25	0.99	0.16	0.40	1.00	5.00	0.31				
13.00	1.11	0.21	0.40	0.50	8.00	0.44				
16.25	1.27	0.30	0.50	0.60	7.00	0.45				
11.75	0.79	0.13	0.60	0.30	6.00	0.33				
14.00	0.99	0.11	0.40	0.30	7.00	0.37				
09.40	1.11	0.28	0.30	0.60	10.0	0.51				
12.75	1.68	0.32	0.40	0.50	11.0	0.68				
09.40	0.99	0.16	0.30	0.40	9.00	0.46				
11.00	1.03	0.11	0.40	0.40	8.00	0.44				
08.75	1.15	0.13	0.10	0.60	11.0	0.55				
13.00	1.25	0.28	0.20	0.60	10.0	0.60				
08.25	0.91	0.21	0.50	0.50	9.00	0.45				
09.25	0.95	0.23	0.30	0.80	9.00	0.44				
15.25	1.35	0.47	0.20	0.50	8.00	0.49				
18.00	1.56	0.51	0.20	0.40	8.00	0.52				

Where; ESP = Expected Sodium Percentage, SAR = Sodium Adsorption Ratio

APPENDIX B

Table 2: Chemical composition of water sampled at dam, main canal, distributaries canal field drains and collector drain of SECTOR **I, II, III** and **IV** and main collector drain. Sampling date: 16/04/2007

Place	pH	EC (ds/m)	CEC(mg/L) Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	ESP (%)		SAR
				Storage Water					
Dam	7.40	0.06	7.21	8.76	2.44	0.61	7.00		0.86
				Main Canal					
Up-stream	7.30	0.05	6.41	7.67	2.28	0.59	8.00		0.85
Mid-stream	7.20	0.07	7.21	10.95	2.28	0.42	10.0		0.76
Down-stream	7.00	0.06	8.82	9.86	2.36	0.51	9.00		0.77
				Sector I					
Dist. Canal	6.95	0.07	8.02	9.86	2.48	0.47	9.00		0.83
Field Drain	7.04	0.23	11.22	9.86	3.28	0.42	9.00		0.91
Collector Drain	7.08	0.32	10.42	17.52	2.80	0.54	8.00		0.72
				Sector II					
Dist. Canal	6.87	0.07	8.82	8.76	2.52	0.56	10.0		0.78
Field Drain	7.09	0.08	12.83	13.14	2.80	0.49	9.00		0.77
Collector Drain	7.04	0.18	9.62	16.43	2.92	0.54	10.0		0.84
				Sector III					
Dist. Canal	7.18	0.05	8.82	9.86	2.36	0.47	9.00		0.83
Field Drain	7.13	0.09	15.23	12.05	2.92	0.42	9.00		0.91
Collector Drain	7.10	0.22	11.22	18.62	3.17	0.51	10.0		0.83
				Sector IV					
Dist. Canal	7.26	0.05	11.22	13.14	2.00	0.63	8.00		0.67
Field Drain	6.99	0.42	16.83	12.05	2.97	0.37	9.00		0.80
Collector Drain	7.08	0.76	11.22	17.52	2.88	0.61	9.00		0.76
				Main Drain					
Main Collector Drain	6.43	1.85	16.03	19.72	2.72	0.66	10.0	0.64	

ASSESSMENT OF IRRIGATION WATER AND SOIL QUALITY IN GALMA IRRIGATION SCHEME, ZARIA, NIGERIA

Othman, M. K., Ismail,H. and Iorhen, O. E.

NAERLS/Department of Agricultural Engineering,
Ahmadu Bello University, Zaria
mkothman@yahoo.co.uk

ABSTRACT

Soil and water samples were collected from Galma I (upstream), Galma II (midstream) and Galma III (downstream) for water quality analysis in the laboratory. The pH, electrical conductivity (EC), concentration of calcium, magnesium, sodium, nitrate, sulphate and chloride of the samples were determined using volumetric and calorimetric methods on the samples. The pH values for water and soil samples collected from the three areas (three at each point or place) ranged from 6.10-6.90 and 5.20-6.60 were mildly acidic. While the average concentration of calcium, magnesium, sodium and potassium was found to be 7.98, 1.23, 7.80 and 10.23 mg/l, respectively. These results were within the acceptable limits of usage for crop production under irrigation. The electrical conductivity of the water ranges from 0.05-0.24 dS/m which shows that the water was good for irrigation. This level of electrical conductivity does not indicate any need of restriction for its use for irrigation. However, good water management practices are recommended to avoid salt build-up in the future.

Keywords: volumetric, calorimetric, mildly acidic, upstream, midstream, downstream

1.0 Introduction

Irrigation is generally defined as the art of application of water to soil for the purpose of supplying moisture essentially for plant growth, providing crop insurance against short duration drought, cooling the soil and atmosphere thereby providing more favorable condition for plant growth and leaching down salts in the soil.

The sources of irrigation water may be river, canal, tank and open or tube wells. Whatever may be the source, some soluble salts are always dissolved in it. However, the nature and quality of dissolved salts depend upon the source of water and its course before use (Paliwal and Yadav, 1976). With poor water quality, various soil and cropping problems such as alkalinity, salinity, etc can be expected to develop. As such, good management practices may then be required to maintain crop production at a profitable level.

The term water management implies total control of the water on the land and in the soil so as to enhance high levels of the water on the land and in the soil so as to enhance high levels of production and reduce damages to a minimum. In Nigeria, emphasis has tended to concentrate on the provision for irrigation of agricultural lands without adequate provisions for drainage of excess water from the plants' soil environment. With poor drainage, excess soil moisture accumulates to seriously hamper the growth of plants and cause deteriorative changes in the soil's physical structure (Nwa, 1982).

Reports of water-logging in Nigerian irrigated lands have also recently begun to emerge. For instance, the Kano irrigation project was established in 1970 but with evidently no provision for effective drainage system. According to Nwa (1982), ground water survey in the area before the project establishment showed that there was no water table existing within 1.5 m of the ground surface even during the rainy season. However, a study recently conducted revealed the high ground water table became a problem in the Kadawa sector of the project within seven years of continuous irrigation (Othman, 2007). The study was aimed at providing baseline data on the water quality of the project and determining whether the quality is acceptable for irrigation purpose. Similarly, the Kaduna State owned Galma irrigation project in Zaria has shown evidence of water-logging due to probably poor water management and inadequate natural drainage system. In addition the project is located in an industrialized area with possibility of industrialized wasted contaminating the irrigation water.

Materials and methods

Description and characteristics of the study area

Galma pilot irrigation scheme is located at 16 km along Zaria-Jos Road. It is located within latitude 11^0 05' North and longitude 7^0 44'. East and covers an area of 350 ha. It is a division of Zaria Irrigation Scheme in Kaduna State which is aimed at training local farmers on when and how to irrigate their farm lands and also to assist in putting the vast fertile land along River Galma under crop production and there were four pumps at Galma II and III.

The daily air temperature at Galma irrigation project is 28.2^OC except in December when it is lowest. The rainy season usually starts in the month of May. Irrigation is practiced from the months of November to May, which are the driest months of the year; hence the climate of Galma is the same with other parts of northern Nigeria marked by wet and dry seasons annually.

The wind blows along the northeast direction as from the month of November to March, which is the harmattern period and then changes direction as from the month of April through October which indicates the rainy season.

Relative humidity of Galma Irrigation Scheme is between 30 and 70% annually. Generally, the wet season from April to October has the highest values of relative humidity because of the rains.

Water sampling

Galma irrigation scheme is a hydro flow system consisting of three pumping stations. The pumping stations PS1, PS2 and PS3 are located at schemes. PS1 commands irrigable area of two hectares. PS2 commands 9ha while PS3 is located at tail end of the downstream.

Nine water samples were collected from River Galma which is the source of the irrigation water of Galma Irrigation Scheme. The scheme is divided into three sections viz: Glama 1, Galma 2 and Galma 3. Galma 1 is between PS1 and new Jos road, while Galma 2 is between new Jos Road and river Bizara and Galma 3 is between river Bizara and PS3.

At Galma 1 and Galma 2, water samples were collected from the river at intervals of 20 m, in three places along the river. A flood was observed to be flooded on the surface in some parts of

Galma 3 resulting in water logging condition. Samples were collected at interval of 20 m in 3 places from where the flood was observed.

Anions determination

Chloride, Nitrate and Sulphate determination

Chlorides were determined using Mohr's method by filtering 20 ml of each sample with a standard silver nitrate ($AgNo_3$) solution of 0.01N. The chloride concentration was therefore calculated using equation 1

$$chloride: MglofCl = \frac{1000\ XnormalityofAgNo3\ used}{Mlofaliquot} \quad \text{.....1}$$

Nitrate was determined with spectrometer after developing a calibration curve by pipetting 1, 2, 3 and 10 ml of 0.01. Nitrate concentration of sulphate was determined by pipetting 20 ml of the samples and adding two drops of sulphuric acid indicator. Then the solution was determined with equation 2.

$$sulphatesMglofSO4 = \frac{1000\ mlofbasaltXnormalityofBasalt}{Mloftitrateused} \text{.....2}$$

Cation determination

Calcium and magnesium concentration were determined by titrating the prepared solution with EDTA solution until the color became a clear blue and the concentration was calculated with equations 3 and 4.

$$Ca++ = \frac{xmlXvolumeofsolution}{10\ XaliquotXsamplewt\ (g)} \text{.....3}$$

$$Mg = \frac{xmlXvolumeofsolution}{10\ XaliquotXsamplewt\ (g)} \text{.....4}$$

The concentration of sodium and potassium were determined with flame photometer.

The samples were centrifuged to obtain a clear solution. The aliquot (liquid quantity of sample) was injected into the flame photometer and concentration of sodium and potassium were read directly from the gauge.

Test for pH

The pH of the soil and water samples was obtained directly by using pH meter made by kent electronic instrument, limited model 1965. The meter was first calibrated using buffers of pH between 4 and 7 which the pH buffers of the samples were obtained by dipping its electrode into the solution and readings directly were taken from a counter.

Results and discussions

Salinity of the water and soil samples

The salinity of the water and soil samples is a good secondary indicator of drainage system performance. The results of the chemical analysis carried out on soil and water samples from Galma 1 (upstream), Galma 2 (midstream) and Galma 3 (downstream) are presented in Tables 1, 2, 3, 4, 5 and 6 for water and soil samples, respectively.

From the results obtained, the pH ranges from 5.20-6.90 for soil and water samples collected from the upstream, midstream and downstream locations. These values indicated that the water and soil are mildly acidic.

The sodium adsoption ratios for water and soil samples from the areas were observed to be far below 10. This implies that for sodicity classification, the water falls into s1 class. The risk of the development of high exchangeable sodium percentage, ESP is minimal when using waters of this quality for irrigation.

The electrical conductivity of the water collected from midstream varied from 0.05-0.24 dS/m and that of downstream varied from 0.60-0.70 dS/m. also the electrical conductivity of soil samples at different depths from 0 cm to 30 cm from Galma 1 and2 varied from 0.15 to 0.55 while that of the downstream varied from 0.43-0.74 dS/m.

Water with electrical conductivities of between 0.7-3.0 dS/m or greater than 3.0 dS/m are restricted for use for irrigation.

Soil sample from the downstream at a depth of 30 cm has electrical conductivity up to 0.74 dS/m and these values pose some concern. This is particularly so since electrical conductivity, EC is the most important parameter contributing to the suitability of a water source for irrigation (Greppi and Pertti 1999). The EC of water is used as a surrogate measure of total dissolved salts (TDS) concentration.

Table 1 chemical properties of soil samples collected from Upstream, Midstream and Downstream

Indicator	Upstream (Galma I)			Midstream (Galma 11)			Downstream (Galma 111)		
	0 cm	15 cm	30 cm	0 cm	15 cm	30 cm	0 cm	15 cm	30 cm
pH	0.60	5.2	6.1	6.3	5.2	6.1	6.22	5.91	5.5
EC (dS/m)	0.15	0.5	0.54	0.3	0.55	0.49	0.43	0.60	0.74
Ca++	8.07	6.22	7.3	5.59	8.07	8.84	6.22	7.37	5.49
Mg++	14.0	1.6	1.5	1.04	1.68	1.48	1.46	0.799	1.21
K+	6.15	9.46	7.15	7.88	6.15	9.46	7.15	6.37	5.37
Na+	11.8	9.13	8.61	10.87	12.61	10.87	9.13	8.61	8.22
$NO3^-$	0.00019	0.0028	0.00018	0.009	0.027	0.000017	0.00018	0.001018	0.0027
SO4 (mg/l)	1.10	1.3	0.98	1.3	1.10	0.99	1.10	0.9	1.3
SAR	5.53	4.62	4.36	5.47	5.71	4.78	4.66	4.26	4.49
Cl (mg/l)	0.4	0.7	0.3	0.6	0.5	0.7	0.4	0.3	0.3

Table 2 chemical properties of water samples collected from Upstream, Midstream and Downstream

Indicator	Upstream (Galma I)			Midstream (Galma 1I)			Downstream (Galma 11I)		
	1st sample	2nd sample	3rd sample	1st sample	2nd sample	3rd sample	1st sample	2nd sample	3rd sample
pH	6.1	6.1	6.1	6.9	6.9	6.9	6.19	6.10	6.10
EC (dS/m)	0.05	0.2	0.2	0.07	0.2	0.24	0.67	0.6	0.70
Ca++	7.98	7.98	5.11	5.11	7.98	6.74	5.00	6.11	6.11
Mg++	1.23	1.83	1.54	1.23	1.83	1.4	0.28	1.60	1.60
K+	10.23	15.34	12.27	14.12	16.34	12.27	10.2	15.2	16.11
Na+	8.57	11.92	11.47	8.83	12.6	11.74	7.83	10.61	11.74
$NO3^-$	0.00018	0.00018	0.00018	0.00027	0.18000	0.00027	0.00027	0.0008	0.00018
SO4 (mg/l)	0.8	1.12	1.1	0.85	1.1	0.8	0.8	0.8	0.8
SAR	3.65	4.81	4.79	4.96	5.69	5.8	4.82	5.41	5.98

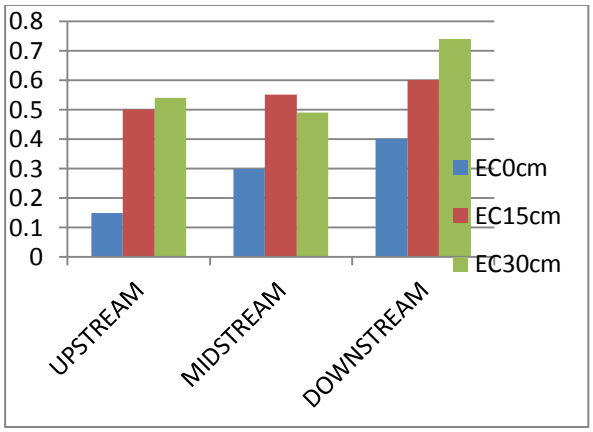


Fig.1a Barchat showing the variation of EC with depth

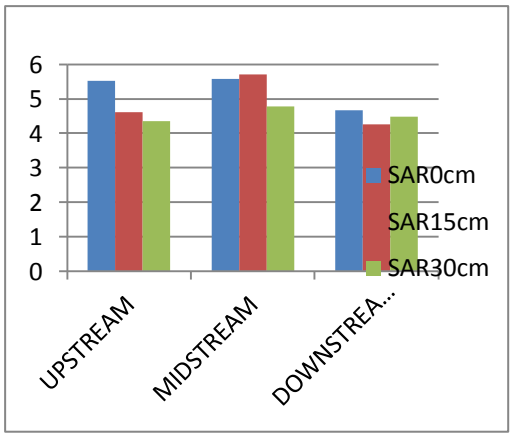


Fig.1b: Barchat showing the variation of SAR with depth

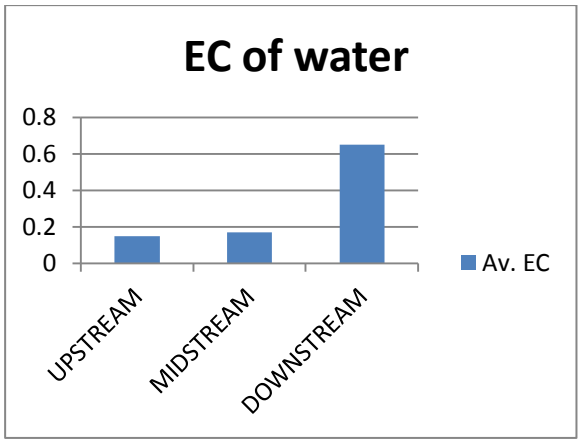


Fig. 2a:Barchat showing the variation of EC along the stream

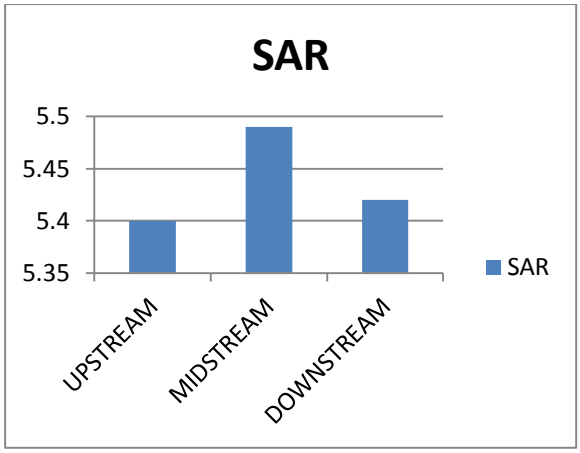


Fig. 2b:Barchat showing the variation of SAR along the stream

From the fig 1a, EC0, EC15 and EC30 mean electrical conductivity at surface 0 cm depth, 15 cm depth and 30 cm depth, respectively.

It can be seen from the histogram that electrical conductivity, EC increased with increase in depth from 0.15 dS/m to 0.4 dS/m at the upstream. Similarly, EC increased with increase in depth from 0.5 dS/cm to 0.6 dS/m at the midstream. While at the downstream, EC at the surface is 0.54 and decreased to 0.49 at depth of 15 cm below the surface. It also increased to 0.74 at depth of 30 cm.

Even with this fluctuation in values of EC, the values are still within the acceptable limit as discussed in Table 2; hence the soil has low salinity and can be used to grow plants with little no likelihood of salinity development.

Furthermore, Fig 2b shows the soil adsorption ratio (SAR) at 0 cm, 15cm and 30 cm for upstream, midstream and downstream. The values of SAR decrease with increase in depth from 5.53 to 436 from 0 cm 30 cm depth at upstream while the variation of SAR at the midstream is not linear, it rose from 5.57 to 5.71 and then fell to 4.78 at depths of 0 cm, 15 cm and 30 cm, respectively. Similarly, the values of SAR at the downstream decreased from 4.66 to 4.26 then increased to 4.49 at depth 0 cm, 15 cm and 30 cm, respectively.

The values of SAR were also found to be within the acceptable limits as shown in Table 3 as being low-sodium-soil that is SAR between 0 and 10 can be used continuously with little danger of development of high exchangeable sodium percentage (ESP).

Figures 1a and 1b show the variation of EC and SAR at upstream, midstream and downstream. In Fig. 2a, EC of water increased from 0.15 through 0.17 to 0.65 from upstream, midstream and downstream, respectively. Here too, the values of EC showed that the water is non-saline and is suitable for irrigation.

On the other hand, the values of SAR of water increased from 5.4 to 5.49 from upstream to midstream and then fell to 4.42 at downstream. But these values can be used continually for irrigation with little or no danger of development of high ESP in the soil.

CONCLUSION

Despite evidence that the scheme has a poor drainage system especially at the downstream, Galma 3 (poor yields reported by farmers through baseline survey research). The soil is non-alkaline but only mildly acidic, the soil pH ranged from 5.20 to 6.60 and the pH of irrigation water only slightly outside the usual range acceptable for irrigation water (6.5-8.4).

Soil/water salinity levels indicated by the electrical conductivities 0.15-0.74 and 0.05-0.7 were not found to be harmful for the development of crops generally. However, there are some concerns posed by soil samples at depth of 30 cm at Galma 3 (downstream) and third sample of water collected at Galma 3, since the electrical conductivity marginally fails within the region suggested for slight to moderate restriction (0.7-3.0 dS/m)

During the course of the study, substantial contamination of the irrigation water by effluents from nearby vegetable oils industries, Sunseed Oil Mill Plc was observed. The chemical composition of these effluents are not known but are suggested to have contributory effects on irrigation water quality.

REFERENCES

Grepi, M and F. Preti (1992) Water Quality in Agriculture in Van Lier. H.N, LS. Pereira and F.R. Steine (1999) IGR Hand book of Agricultural Engineering Vol 1 (land and water Engineering) American Society of Agricultural Engineering, Michigan.

Nwa, E.U (1982) Drainage of irrigation area using the bamboo (Arundinaria amabilis) as field drainage material. Proc. 6th National Irrigation Seminar, A.B.U pp 164-170.

Paliwa, K.V (1972) Irrigation with saline water. Water Technology Centre, India Agricultural Research Institute, New Delhi.

DEVELOPMENT OF IRRIGATION FIELD LABORATORY: DESIGN, CONSTRUCTION AND CALIBRATION OF MICRO WATER RETENTIONAND OFF-TAKE STRUCTURES

H. Ismail[1], M. K. Othman[2]and N. J. Shanono[3]

Department of Agricultural Engineering Ahmadu Bello University, Zaria
National Agricultural Extensions and Research Liaison Services (NAERLS)
Ahmadu Bello University, Zaria
Department of Agricultural Engineering Bayero University, Kano

ABSTRACT

Reservoir and off-take structures of 4000 litres and 150 litres capacity were designed and constructed using mixing ratio of 1:2:4 of cement, sand and gravel, respectively at the Agricultural Engineering Departmental Irrigation Field Laboratory, Bayero University, Kano. Pipe of 3-inch diameter and a control valve were installed to connect the off-take to the reservoir. Water was released from the reservoir to the off-take through the pipe and discharges were determined at different heads at the outlet of the basin. Coefficient of discharge was found to be 0.08218; values of R^2 for discharge against head and discharge against $h^{3/2}$ were determined to be 0.9959 and 0.983, respectively.

1. INTRODUCTION

Reservoirs are structures constructed on rivers, or natural streams to store or detent water for flood control and regulate stream flow with variable flow rates over the year. Thus a reservoir is an essential component in irrigation and water supply systems where it plays an important role to make the system adequate and dependable. (Duggal & Sani, 2007).

Reservoir is created with the impounding of run-off from the catchments upstream by construction of a retention structure across a river or stream. It stores surplus water during the period of excess flow for a considerable period of time so as to maintain continuous supply and controlled flow for irrigation. (R.K Sharma, T.K Sharma, 2004).

Water pressure corresponding to full reservoir level constitutes the major external force acting on the dam. The water pressure acts horizontally and its intensity varies triangularly with zero intensity at the water surface. A river does not carry the same quantity of water throughout the year, and may carry large quantities in the other parts of the year. A storage reservoir is constructed to store the excess water during the period of large supplies, and release it gradually as at when it is needed (Punma & Panda, 1990).

According to Craatz & Mahajan (1994), a stilling basin is a basin with protected walls and flow, and which is filled with water. Its function is to convert the energy of flowing water into turbulence, so that the flow enters at low speed into the canal downstream where flow velocities can be high, such as intake structures, off-takes, culverts, weirs or drop structures. Fast flowing water is highly erosive and can easily damage a canal bank or bed, and so the energy of this fast-flowing water must be dissipated in order for it to flow smoothly into the downstream canal section.

The micro retention and off-take structures were constructed for field laboratory experimentation and teaching purposes and function in the same principle with that of retention structures across rivers which are mainly multimillion naira civil engineering structures.

2. MATERIALS AND METHODS

Site selection

The area is located at the proposed Agricultural Engineering Departmental Irrigation Field Laboratory at the western part of the school, at latitude 9` 33 S to 12` 37 N and longitude 7` 34 W to 9` 29 E. The area has an average rainfall of 600 mm, temperature ranging from 30`c to 33`c in March to May and lowest temperature of 10`c around December to January and has a savannah vegetation cover. The soil is predominantly clay-loamy soil, sloping from north to south (Anonymous, 2002).

Location of the reservoir

The reservoir is located at the proposed Departmental IrrigationField Laboratory where Wash bore was constructed. Water is pumped into the reservoir using centrifugal Pump.

Survey of the area

A topography survey of the area was carried out using dumpy levelling instrument. Two points were selected and measured using measuring tape and were aligned with wooden pegs. First point was located at the reservoir site while the other one at the point of application. Dumpy levelling instrument was placed on the ground and adjusted until all the settings were stable. Staffs were used to take levels at two points for establishment of slope.

Determination the Reservoir Elevation

Two points (A and B) were marked to determine the elevation of the reservoir. Point A located at the reservoir site while point B at the point of application. Levels were taken and recorded using dumpy levelling instrument at two points. Different in level between the two points was determined so as to have a reservoir at the spot height, thereby having a flow by gravity from the reservoir down to the point of application.

Design and Construction of the Reservoir and Off-take

Reservoir capacity, freeboard, flow velocity through the gate, forces and capacity of an off-take, e.t.c. were designed and calculated using Analytical method.

A hole was drilled using soil auger and measuring tape where depth to firm soil level, profile and properties of soil were determined. Volume of soil in the four marked corners was excavated at depth of 1.5 m length and width of 0.5 m each. Blinding of about 0.3 m thick was made at the base of each hole using a cement and sand mix ratio of 1:2 (Arthur $ George, 1978).

Five pillars were made at corners and centre of the slab by making a formwork using wooden planks. Basket made up of 10 mm diameter rods were placed on the blinded area of each hole. Concrete was casted using a mix ratio of 1:2:4 of cement, sand and gravel, respectively (For water retention and supporting structures).

Formwork was made using wooden planks, and 10 mm diameter rods were arranged and placed on the pillars at interval of 0.2 m. Four walls of the reservoir were constructed using 6 inch blocks to the designed level. Tie beam was made with reinforce concrete on top of the walls of the reservoir.

A floor of about 0.15 m thick was made on the slab, plastering was made all round the reservoir to avoid cracking and minimize seepage.

Stilling basin of 0.5 m x 0.5 m x 0.6 m, length, width and depth, respectively with an outlet of 0.3 m x 0.3 m, width x depth respectively was constructed at about 0.7 m from the reservoir using a concrete mix ratio of 1:2:4 of cement, sand and gravel, respectively. A gate made up of sheet of metal was constructed and placed at the outlet of the basin for calibration.

Curing

Curing of the structure was made twice a day (in the morning and in the evening) for three days so as to strengthen the structure.

Calibration of the Off-take

An outlet was made at the reservoir site and pipe of 3 inch diameter with a control valve were installed. Water was released from the reservoir through the pipe to the stilling basin where discharge was determined and recorded at different heads and time.

3. RESULTS AND DISCUSSION

Proper site for the reservoir was selected about 1 m away from the water source and at a depth of 1.5 m.

From the results obtained, the constructed reservoir has a capacity of 4000 litres of water and a free board of 0.577 m was provided so as to avoid over flow of water when it reaches the maximum height.

Form work for slab and pillars was made with wooden planks using two men in two days, five pillars and slab were constructed with a concrete mix ratio of 1:2:4 of cement, sand and gravel respectively and 10 mm diameter rods using 2 men in 4 days. Four side walls of reservoir were constructed with 6 inch blocks using 2 men in 1 day, tie beam was made on top of the walls with reinforce concrete, floor and cement plaster were made in 3 days using 2 men.

Stilling basin of 150 litres capacity of water and area of outlet of 0.09 m^2 was constructed with 6 inch blocks and a gate made up of sheet of metal was constructed at the outlet using 2 men in 1day.

From the results obtained in Table 4.5 a graph of discharge Q against h was plotted and value of R^2 was found to be 0.9959. This could be seen from the way most of the measured values almost fall on the trend line within the range. The close fit between measured values and the trend line over a wide range of values (R^2 = 0.9959) indicates that the structure (off-take) could be used to calibrate other structures like weirs, drop, flume, e.t.c. in the channel.

Also using the graph of discharge Q against $h^{3/2}$ above a slope of 0.0728 was determined and the value of slope was used to equate the equation of straight line with that of discharge.Value of coefficient of discharge C_d was found to be 0.08218 using the two equations. This shows that coefficient of discharge C_d can be determined using graphical method.

Table 1: Features of the Reservoir and off-take

1.	Reservoir capacity	4000 litres
2.	Free board	0.577 m
3.	Weight of tank	9.796 kN
4.	Supporting force from the base	39.24 kN
5.	Area of outlet of an off-take	0.09 m^2
6.	Flow velocity through the gate	2.43 m/s
7.	Area of each pillar	0.04 m^2
8.	Volume of concrete	0.5 m^3
9.	Dead load	12 kN
10.	Area of slab	3 m^2
11.	Volume of concrete for slab	0.3 m^3
12.	Mix ratio of cement, sand and gravel	1:2:4

Table 2: Calibration of off-take Structure

S/N	Head h(cm)	√h	Time (sec)	Volume(L)	h^3/2	Discharge(l/s)
1	0	0.0000	10	0	0.0000	0
2	1	1.0000	10	2.5	1.0000	0.25
3	2	1.4142	10	5.1	2.8284	0.51
4	3	1.7321	10	7.5	5.1962	0.75
5	4	2.0000	10	10	8.0000	1
6	5	2.2361	10	12.5	11.1803	1.25
7	6	2.4495	10	15.1	14.6969	1.51
8	7	2.6458	10	17.6	18.5203	1.76

S/N	Head h(cm)	√h	Time (sec)	Volume(L)	h^3/2	Discharge(l/s)
9	8	2.8284	10	20.1	22.6274	2.01
10	9	3.0000	10	22.6	27.0000	2.26
11	10	3.1623	10	25.5	31.6228	2.55
12	11	3.3166	10	28	36.4829	2.8
13	12	3.4641	10	33	41.5692	3.3

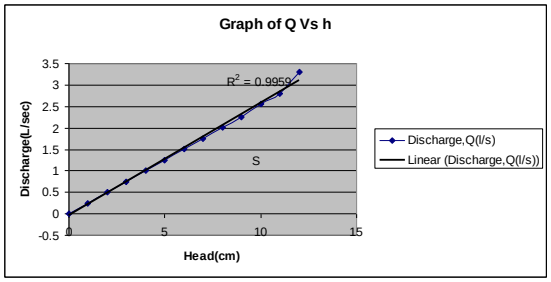


Fig. 1: graph of Discharge at the off-take against Head

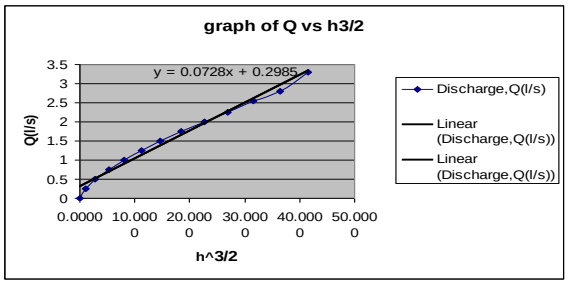


Fig. 2: graph of Discharge at the off-take against $h^{3/2}$

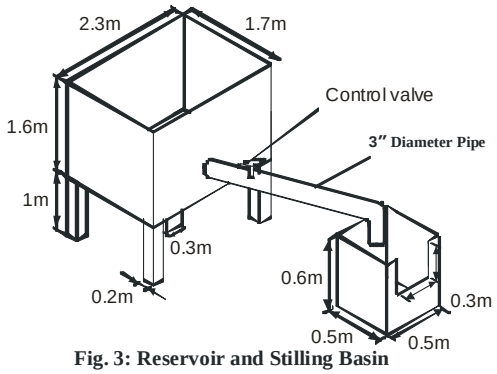


Fig. 3: Reservoir and Stilling Basin

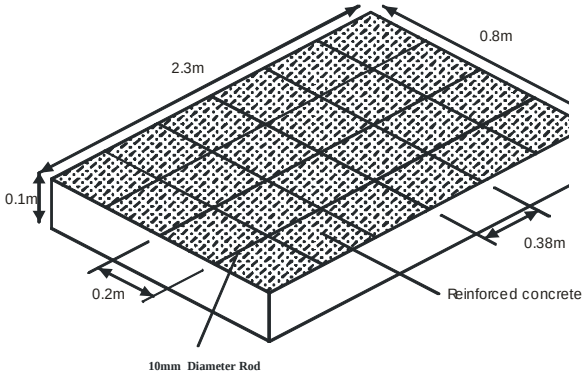


Fig. 4: Slab

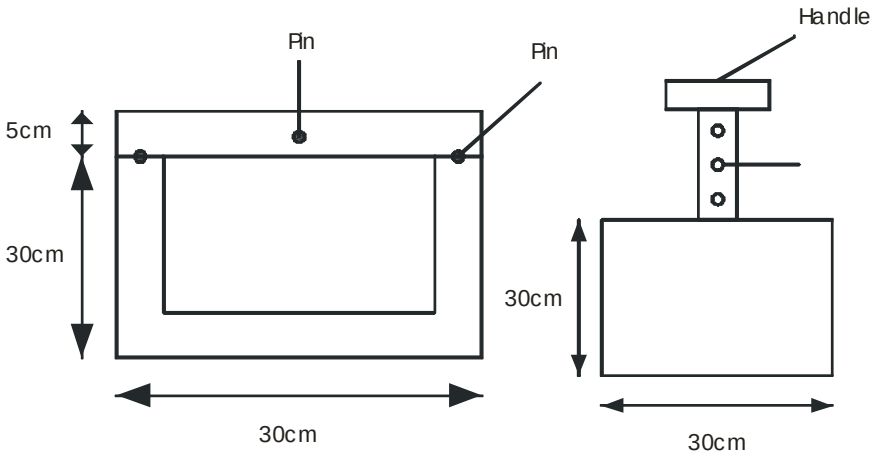


Fig. 5: Frame and Sluice Gate

CONCLUSION

Water storage reservoir is an important component of Irrigation Field Laboratory. It can be used with an off-take structure to store water, control flow and release into canal network for distribution.Also, results obtained can be used to determine coefficient of discharge through the opening. And off-take structure could be used to calibrate other structures such as weirs, flumes, and drop, e.t.c.

REFERENCES

Anonymous (2002). Tropical Agriculture in Nigeria. Pp33-40
Arthur H.N., George W. (1997).Design of concrete structure. M.C. Graw-Hill International edition. Pp643-650.
Craatz D.B., I.K. Mahajan (1994). Small Hydraulic structures. Water resources Development Division. F.A.O.
Duggal K.N., Soni J.P. (2007).Elements of water resources engineering. New age International Ltd publishers. Pp298-331.
Punmia B.C., Panda, B.B Lal (1990). Irrigation and water power Engineering. Standard Publishers Distributors. Pp243-286.
R.K. Sharma, T.K. Sharma (2004). Irrigation Engineering. S.Chard & company Ltd. Pp435-437

WATER BUDGET FOR MAIZE AND SORGHUM IN SAMARU ZARIA, NIGERIA

Othman, M.K. H. Ismail and S. Mustapha
NAERLS/ Ahmadu Bello University, Zaria
mkothman@yahoo.co.uk

ABSTRACT

A study to determine the most suitable time of planting of maize and Sorghum during wet season was conducted. The suitability of the planting was on the basis of seasonal rainfall pattern in Samaru. The study was done by analyzing the 10 years climatic data of Samaru and designing a suitable water budget to meet the water requirement of sorghum and maize. Design rainfall of Samaru was determined, evapotranspiration of Samaru was also determined using Blaney-Criddle model and actual evapotranspiration of both crops were calculated by considering the crops coefficient factor of various growing stage. A water budget for both crops was made by plotting the evapotranspiration of both crops on line graph together with the design rainfall of Samaru. Three different planting periods were considered, thus; 1st to 10th days of June, 11th to 20th days of June and 21st to 30th days of June. Based on the design rainfall at 67% reliability of occurrence or exceedance, an expected annual rainfall of 780 mm in Samaru was determined. The total water requirement for sorghum from planting to harvest when planted between; 1st to 10th days of June, 11th to 20th days of June and 21st to 30th days of June were determined to be 556.4 mm, 545.7 mm and 537.1 mm, respectively. And for maize from planting to harvest when planted between; 1st to 10th days of June, 11th to 20th days of June and 21st to 30th days of June were determined to be 563.1 mm, 551.3 mm and 539.3 mm, respectively. The suitable planting period of sorghum in Samaru based on the seasonal rainfall pattern is between 1st to 10th days of June, when the crop is not likely to suffer water deficit. While the suitable planting period for maize were between 21st to 30th days of June.

1.0 Introduction

Water is one of nature's most precious resources, and one that farmers worldwide must utilize effectively in order to meet the ever increasing demand for food. A shortage of water is one of the most common factors limiting crops production. To overcome these limitations, a water budget is becoming increasingly important in the dry land areas, such as arid and semi arid regions of Nigeria. Knowledge of soil water properties, crop coefficient and climate helps farmers to understand the interaction between the water needs for plants and the water availability in the soil. Using this knowledge, the researcher can create water budgets for seasonal planning to assist farmers.

Water Budgets for crops is an important aid for planning, implementation and monitoring of water requirement for plants, they follow the same principles as financial budgets, in that they calculate the amount of seasonal rainfall of a particular area and matched it with the total amount of water required for crops from planting to harvesting. Poor water budgets for crops could lead to serious reduction in crop growth and consequently reduces the crop yield (ASABE, 2011).

Water availability to crops during cropping season is the most important factor among the climatic factors, which influence the pattern and productivity of rain-fed agriculture in Nigeria.

Pronounced difference exists in the length of growing season in Nigeria along its North-South axis due to differences in the distribution and amount of annual rainfall (Kowal & Kassam, 1974). Apart from irrigated lands, rainfall is the major source of water for agriculture, and a reduction of 50 percent seasonal rainfall may result in a total crop failure in a given area (FAO, 2005). Thus, budgeting of available rainfall to match with the crops water requirement is an important tool for crop productivity, prevention of crops failure and increasing of yield. Therefore water budgeting is an important tool for seasonal planning in crop production under rain-fed agriculture.

In the 1970s, Kowal & Kassam had worked on water budget for Maize and Sorghum in Samaru. Their work provided a total estimate of 700 mm and 486 mm of water for the production of Maize and Sorghum respectively, in Samaru. Maize and Sorghum are the major cereals and are some of the important food, feeds and industrial crops in Nigeria. They are some of the dominant grain crops in the Savannah zones. The production of these crops is indeed poverty reduction tools in the country; for example, the annual requirement for Maize has been estimated at about 14 million MT while the current production is about 7.7 million MT, which indicated a huge production shortfall of about 6.3 million MT (NAERLS, 2009). Therefore to bridge this production gaps, an important measure have to be made, one of them is a good crop seasonal planning to avoid crop failure to obtain optimum yield. One of the major component of seasonal planning is water budget especially in the interface of climatic changes, which is a major challenge in Agriculture.

MATERIALS AND METHODS

Study area

Samaru is a town located at the northern Nigeria that has a wide range of climatic conditions, classed as dry sub-humid climate. It is 686 m above the sea level and has the latitude and longitude of 11^{o}, $11^{'}$ N and 7^{o}, 37'E respectively. It has the average annual rainfall and average annual evaporation of 1100 mm and 1880 mm, respectively. The climate description of Samaru makes it favorable for growing varieties of cereal crops such as Sorghum, Maize, Millet, Guinea corn, etc., and some other legumes such as Groundnut, Cowpea, etc.

Data collection and analysis

A 10 year climate data from 2001 to 2010 was obtained from the meteorological Station of Institute of Agricultural Research (IAR), Ahmadu Bello University Zaria, in Samaru where the study was conducted. The climate data obtained are Daily Rainfall, Daily Air Temperatures, Daily Relative Humidity, Average Wind Speed, Daily Sunshine Hours etc. The data were obtained for the purpose of estimating seasonal water requirement of the selected crops.

Crops reference data collected were crop varieties, growing periods (number of days), time of planting, growing stages, crop coefficient (kc) at different growing stages, Temperature range and water requirement . The data was obtained from Department of Agronomy and Seed Production Unit of Institute for Agricultural Research, Samaru, ABU, Zaria and also from some literatures.

The rainfall record was for the period at the beginning of rainy season, which normally starts from April to October of each year. The record was for the 10-year period. The amount of rainfall for each 10 days from April to October of the 10 years period (2001-2010) was added and considered to be the quantity of rainfall for that period. The values of rainfall within a given

interval for each year was then collected together and ranked starting from the interval with the highest rainfall recorded to the year with lowest recorded value. The design rainfall was determined based on 67 % probability of occurrence for each of the 10-day interval

The design rainfall for each interval was then determined based on the 67 percent probability of occurrence or exceedance using the eqn:

$$M = \frac{p(N + 0.25) + 0.375}{100} \qquad (1)$$

Where:

p = reliability of Rainfall event in percentage

N = length of the series

This implies that in 67 percent of the time, (in 2 years out of three) the given rainfall record would be equaled or exceeded. This analysis was also repeated for all the intervals to get design rainfall events for a whole period (April to October) using the 10 year records.

Reference Evapotranspiration (ETo) Calculations

The evapotranspiration calculated was for the period of wet season, which normally commences from April to October of each year over the 10-year duration using the eqn:

$$ETo = p\,(0.46Tmean + 8) \qquad (2)$$

Where:

ETo = Reference crop evapotranspiration (mm/day)

Tmean = mean daily temperature (^{0}C)

P = mean daily percentage of annual day time hours

The ETo of each year was summed up for 10-day interval. The 10-day ETo was used for the determination of the crop water used within the days from the beginning to the end of the wet season.

The average evapotranspiration ETav. Was determined using Eqn. 3:

$$ETav. = \frac{\sum_{i=1}^{N} ETo}{N} \qquad (3)$$

Where:

ETo = 10-day ETo for each month within the season

N = number of years = 10

Crop water requirement

The average computed values of ETav for each 10- day interval were used for the plotting a graph for the season. The ETav was considered as the crop water requirement for the interval.

Also, using the average values of ETo, the water requirement of both Maize and Sorghum at different growing stages were determined using Eqn:

$ETa = kc \times ETo.$ (4)

Where:

ETa = Actual evapotranspiration of a given crop in mm/day

kc = crop coefficient

ETo = reference evapotranspiration in mm/day**.**

Reference evapotranspiration (ETo)

The reference evapotranspiration of Samaru was calculated using Eqn:

$ETo = c\,(W.Rn + (1-W).f(U).(ea-ed))$ (5)

Where:

(ea-ed) = vapour pressure deficit i.e the difference between saturation vapour pressure (ea) at Tmean in mbar and actual vapor pressure (ed) in mbar, where ed = ea.RH/100

f(U) = wind function of $f(U) = 0.27(1+U/100)$ with U in km/day measured at 2 m height.

Rn = total net radiation in mm/day or Rn = 0.75Rs-Rnl

Where Rs is incoming shortwave radiation in mm/day either measured or obtained from Rs = (0.25+0.50n/N) . Ra is extra-terrestrial radiation in mm/day; n is the mean actual sun shine duration in hours/day and N is maximum possible sun shine duration in hour/day. Rnl is net long wave radiation in mm/day and is function of f(T), of actual vapour pressure, f(ed) and sun shine duration, f(n/N), or

Rnl = f (T).f (n/N).f(ed)

W = temperature and altitude dependent weighting factor

C = adjustment factor for ratio Uday/Unight, RHmean and for Rs.

Actual Evapotranspiration (Etc)

The actual evapotranspiration of both crops were determined using Eqn 6:

$ETa = kc \times ETo.$ 6

Where:

ETa = Actual evapotranspiration of a given crop in mm/day

Kc = crop coefficient

ETo = reference evapotranspiration in mm/day

The Eqn used the climate data of Samaru and the averages of 10-day intervals of up to 10 years were calculated

Matching crop water requirement with design rainfall

The crop water requirement was determined at different growing stages, it was then plotted together with the design rainfall values on line graphs, this was done to obtain a suitable planting period of both crops (i.e. maize and sorghum) and also to match the water requirement of both crops with the seasonal rainfall pattern of the study area.

Three different planting times were considered for the selected crops. The times were; June (1-10) days, June (11-20) days and June (21-30) days. Graphs for the three planting period were plotted with the design rainfall values.

Design Rainfall

The design rainfall for each interval was calculated based on the 67 percent probability of occurrence or exceedance. The analysis was done for the 210 intervals to get the design rainfall event for the 10-day interval up to 10 years period, in which the 21 intervals were determined to be the designs.

RESULTS AND DISCUSSION

Fig. 1 shows a graph of design rainfall events in Samaru. The rain normally starts from the last week of April with low quantity and reaches a peak value in the period of August and ends normally in the middle of October. Therefore the total number of months for wet season in Samaru is five months and two weeks, 165 days approximately, which is nearly close with the 160 days as obtained from the literature. The period has a total annual design rainfall of approximately 780 mm, which is less than average value of Kowal & Andrews in 1973, but in their work they never considered the 67 % probability of occurrence. The design value of 780 mm can adequately meet the crop water requirements of most rain fed crops.

Fig. 2 shows the graph of the average reference evapotranspiration for 10-day interval in Samaru during wet season. The peak value occurs in April while the lowest value in the month of October.The month of April has the high temperature, low humidity with high daily wind speed, which is responsible for high evapotranspiration.

Based on the results obtained, when sorghum is planted in Samaru between1st to 10th days of June, it is likely to suffer a slighter water deficit from the period of 21st June to 20th July which corresponded to the vegetative stage of growth of the crop (Doorenbos, 1998). However, at that period sorghum is less sensitive to water deficit. Hence, the deficit has no significant effect on the growth and yield of the crop. The crop may be harvested between the period of 11st and 20th

October when the rainfall quantity is less and likely simplifies the harvesting exercise due to moderate moisture contents of the grain.

Never the less sorghum is traditionally left on the farm to completely dry before harvest. While if the maize is planted in Samaru between 1st to 10th days of June, it may likely suffer a water deficit from the period of 21st June to 30th July which corresponds to the flowering growth of maize, and at that period maize is sensitive to water deficit (Doorenbos, 1998), the maize may also be harvested between 21st to 30th days of September when the moisture contents of the grain and environment may be too high,which will make the harvesting exercise difficult.

When sorghum is planted in Samaru between 11th to 20th days of June it is likely to suffer a small water deficit from the period of 11th July to 20th July which correspond to the end of flowering stage to the beginning of yield formation stage of growth of sorghum and at that period sorghum is more sensitive to water deficit (Doorenbos, 1998), it may also suffer another water deficit during ripening stage of growth. However, if Maize is planted in Samaru between the period of 11th to 20th days of june, it may also suffer a little water deficit from the period of 11th to 20th july wich correspond to the flowering stage of growth of maize, and at that period maize is most sensitive to water deficit (Doorenbos, 1998), and it may be harvested between the period of 1st to 10th days of october when the moisture contents of the grain and environment will be high and making the harvesting exercise to be difficult.

When sorghum is planted in Samaru between 21st to 30th June, it may not likely suffer any water deficit until at the period from 1st to 30th days of October which correspond to ripening stage of growth of sorghum and at that period sorghum is not sensitive to water deficit (Doreenbos, 1998), but the deficit is large to the extend it may cause damage in yield of the crop and the harvesting exercise may be carried out in the low moisture contents condition. And if Maize is planted in Samaru between 21st to 30th days of June, it may not suffer any water deficit until from 1st to 30th days of October which correspond to the repining stage of growth of maize (Doorenbos, 1998), and at that period Maize is less sensitive to water deficit and it may be harvested in a moderate moisture content of grain and environment.

Often all the three planting periods considered, the suitable planting period of sorghum in Samaru during wet season is between 1st to 10th days of June, which is closely with the period provided by Kassam & Andrews in 1975, because of the insensitivity of sorghum to water deficit at the period when draught may occurred and the harvesting exercise may be within the period when the moisture contents of the grain and the environment is moderate. While for the maize, the suitable planting period in Samaru is between 21st to 30th days of June, which is also nearly with the period recommended from literature (NAERLS, 2009), because the draught may occurred at the ripening stage of growth of Maize, when the water sensitivity of Maize is less (Doorenbos, 1998), and the harvesting exercise may be carried out at suitable moisture content of grain and the environment.

The total Etc of both Sorghum and Maize when planted in Samaru at suitable planting period are 556 mm and 540 mm respectively and are within the range of values provided by Doorenbos in 1998 and Kowal & Andrews in 1970s.

Kc and Etc of Maize and Sorghum when planting in Samaru between 1st -10th, 11th -20th and 21st - 30th days of June

Table 1

Period	kc						Planting period Et					
	1st – 10th		11th -20th		21st -30th		1st – 10th		11th -20th		21st -30th	
	Maize	Sorgh-um	Maize	Sorghum	Maize	Sorgh-um	Maize	Sorghum	Maize	Sorghum	Maize	Sorghum
APRIL	0	0	0	0	0	0	0	0	0	0	0	0
MAY	0	0	0	0	0	0	0	0	0	0	0	0
JUNE	0.4	0.4	0	0	0	0	23.712	23.712	0	0	0	0
JULY	0.775	0.725	0.775	0.725	0.4	0.4	44.7795	42.427	44.7795	41.891	23.112	23.112
AUG.	0.95	1.075	0.775	1.075	0.775	0.725	52.155	59.018	42.548	59.018	42.548	39.803
SEPT.	1.125	0.775	1.125	1.075	1.125	1.075	59.4	40.92	59.4	56.76	59.4	56.76
OCT.	0	0.525	0.85	0.775	1.125	0.775	-	24.602	39.831	36.317	52.7175	36.317

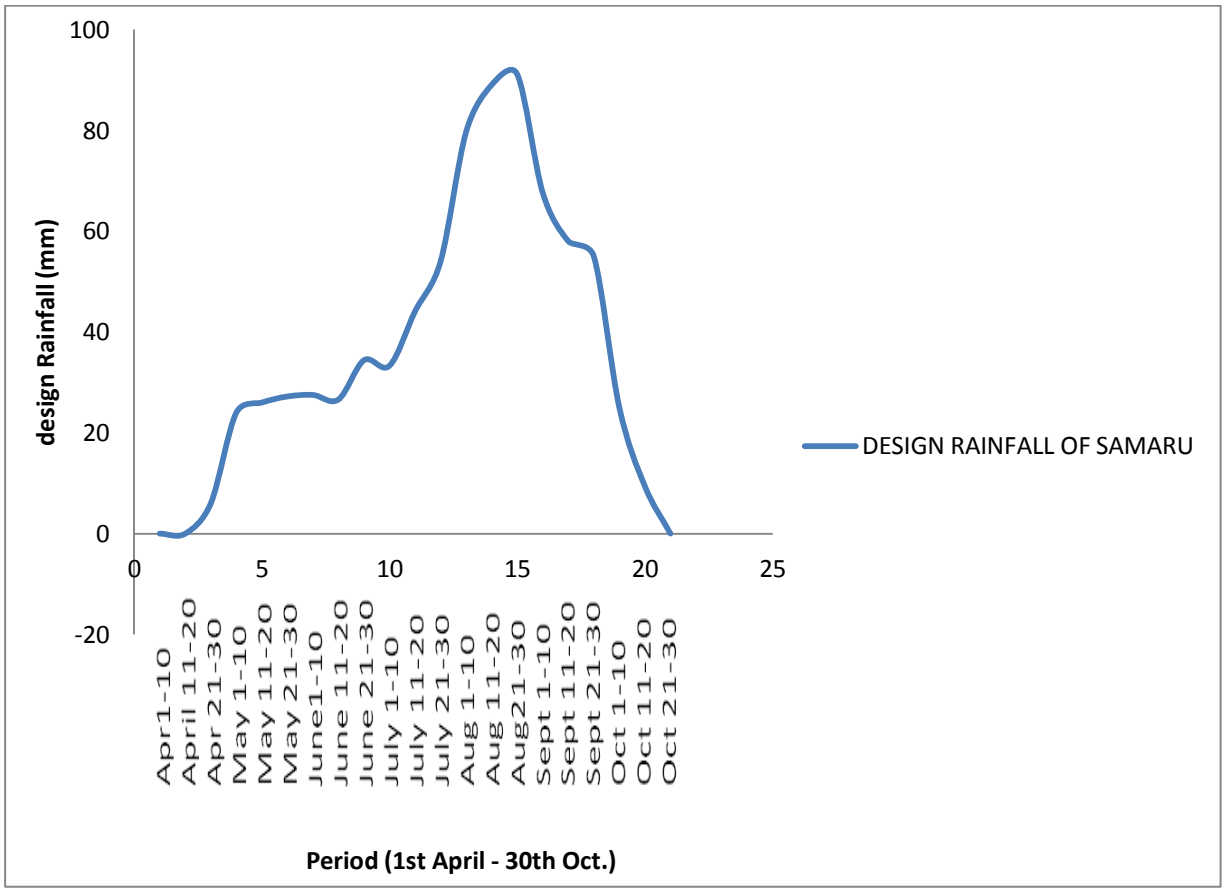


Fig. 1Design rainfall graph for Samaru (from 1st April – 30th Oct)

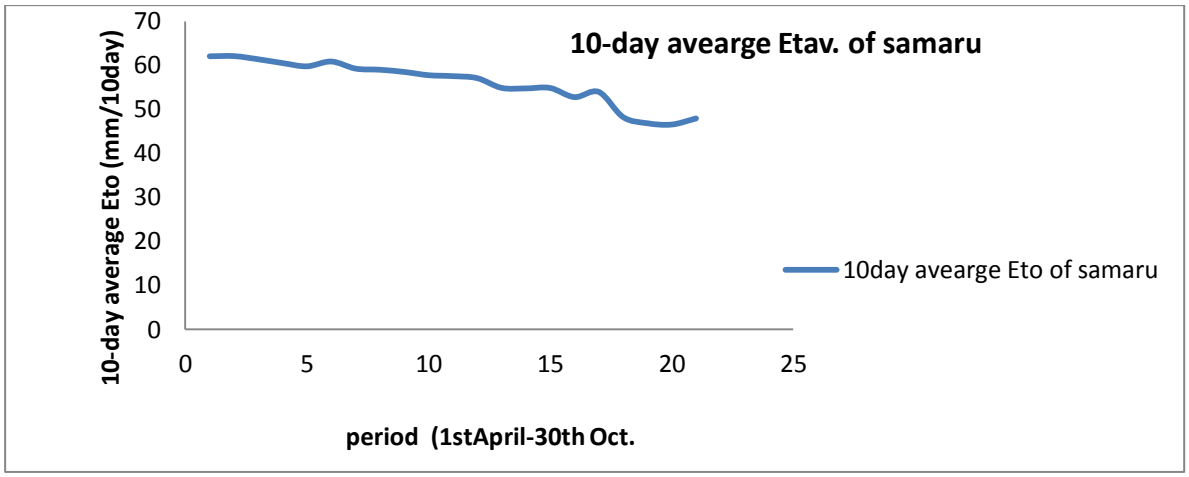


Fig.2 average Etav. graph for Samaru from (1st april-31st Oct.)

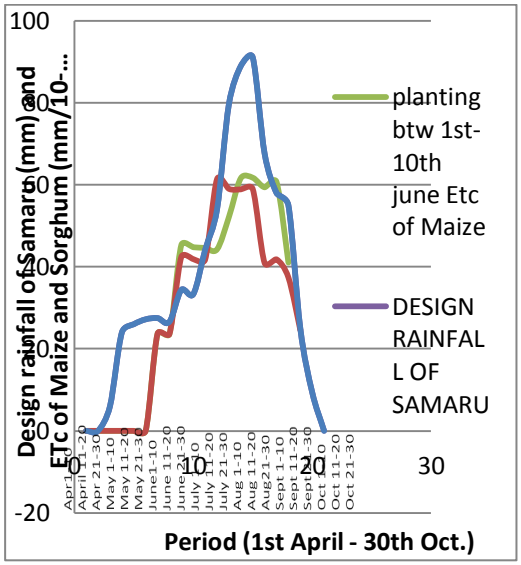


Fig.3 graph of Etc (Maize & Sorghum) and design rainfall of samara when planted between 11th – 20th Jun

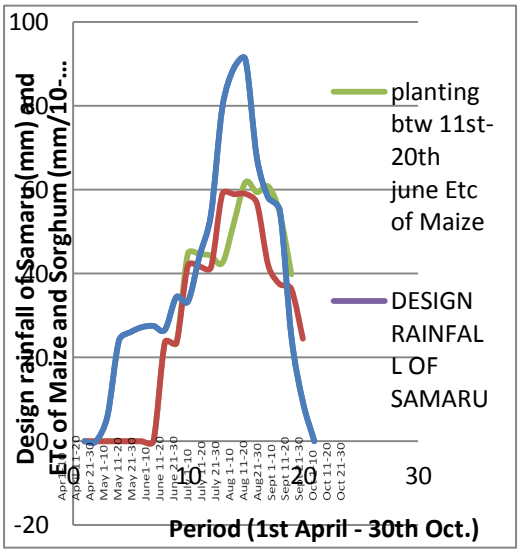


Figure 4 Graphs of Etc (Maize & sorghum) and Design rainfall of samaru when planted between 11st to 20th of june.

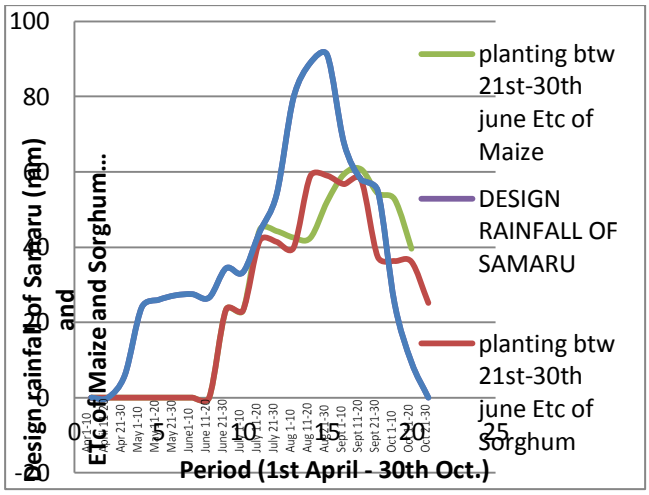


Figure 5 Graphs of Etc (Maize &Sorghum) and Design rainfall

of samara when planted between 21st -30th October

CONCLUSION

The total water requirement for sorghum from planting to harvest when planted between; 1st to 10th days of June, 11th to 20th days of June and 21st to 30th days of June were determine to be 556.4mm, 545.7mm and 537.1mm, respectively. And for maize from planting to harvest when planted between; 1st to 10th days of June, 11th to 20th days of June and 21st to 30th days of June were determined to be 563.1mm, 551.3mm and 539.3mm, respectively. The suitable planting period of sorghum in Samaru based on the seasonal rainfall pattern are between 1st to 10th days of June, when the crop is not likely to suffer water deficit. While the suitable planting period of maize in Samaru based on the seasonal rainfall pattern are between 21st to 30th days of June.

REFERENCES

A.H. Kassam & D J Andrews (1975) Effect of sowing date on growth, development and yield of photosentive Sorghum at Samaru, Nigeria.

ASABE (2005)publication on water availability of crops

J. Kowal & D. J. Andrews (1973) Pattern of water availability and water requirement for grain sorghum production at samaru, Nigeria.

J. M. Kowal & A. H. Kassam (1974) Water use, energy balance and growth of maize at Samaru, Nigeria.

J. Doorenbos (1988) Yield Response to Water.

M. K. Othman (2009) Irrigation Water Management and System Evaluation unpublished Lectures' note

Onyibe, J. E., B. Badu-Akpraku, A. Menkir, (2009) Production of drought tolerant maize in Nigeria. Published by National Agricultural Extension & Research Liason Services (NAERLS), A B U Zaria, Nigeria.

Yakubu, Achile Abubakar (2009) Analysis of rain water data for designing of water harvesting system in Usman Danfodio Hall, Samaru unpublished B.Eng Project Report submitted to Agric. Eng. Dept, ABU, Zaria, Nigeria.

BACTERIOLOGICAL ANALYSIS OF HAND- DUG WELL WATER IN DEMSA LOCAL GOVERNMENT AREA, NIGERIA

Tya, T.S.K., Umaru, A. B. and Barmamu, B. R.

Department of Agricultural and Environmental Engineering,
School of Engineering and Engineering Technology,
Modibbo Adama University of Technology, Yola.
e-mail: tsktya@gmail.com.

ABSTRACT

Water samples were collected from four different hand-dug wells designated as W_1, W_2, W_3 and W_4 from Farai, Borrong and Dong in Demsa Local Government Area, Adamawa state. 4 samples were taken from each location making a total of 12 samples on each day. Water samples were taken at 7days interval for 42 days for bacteriological analysis. The mean range was 6-190 MPN per 100 ml for total coliforms and 3-92 MPN per 100 ml for faecal coliforms. The highest count was consistently found in Well (W_2) located in Borrong (located near stagnant water). The findings showed that the water from all the wells in the study area did not meet the World Health Organization (WHO) standard for drinking water and thus, the water should be treated before drinking.

Key word: Bacteriological analysis, Hand –dug well, water, faecal, coliform

1.0 Introduction

Water is no doubt one of the most essential resources on earth and remains man's prime need in his environment. It is also a fact that portable water supply is lacking in many communities despite being one of the most abundant resource on earth. It is therefore important that the relationship between water quality and health be fully appreciated by all concerned. According to Mustapha and Yusuf (1999), poor water quality can pose health problem enough to threaten human life if consumed. The need for water treatment before consumption cannot be over emphasized, but irregularity or acute shortage of portable water to the populace has lead to people drinking water from hand-dug wells and other sources including streams and ponds.

The pollution of ground water sources may be from industries, agricultural and domestic wastes. According to Ibe and Okplenye (2005), industrial pollution may involve seepage of used water containing chemicals such as metals and radioactive compounds, or contaminated water from damage pipelines that infiltrates into the ground water and can be in hand dug wells. Also, domestic pollution may involve seepage from septic tanks, pit latrine, cesspools and privies. In addition, agricultural pollution is also from irrigation and runoff water carrying fertilizers, pesticides, herbicides and faecal matter to the water source. Environmental pollution may be caused by sea water intrusion into coastal aquifer. However, Chukwurah (2001) said World Health Organisation (WHO, 1986) recommended that wells should be located at least 30 m away from latrines and 17 m from septic tanks.

According to (Okafor, 1985; Okpokwasili and Akujobi, 1996), the presence of faecal coliforms or *Escherichia col* is an indicator for the presence of water borne pathogens. Bacteriological examination of water is therefore a powerful tool in order to foreclose the presence of micro-

organisms that might constitute health hazards (Singh and Neelam, 2011). However, World Health Organization (WHO) recommended that no faecal coliform should be present in 100 ml of drinking water. Good quality water should be odourless, colourless, tasteless and free from faecal contamination and chemicals in excess of WHO tolerable levels.

Most of the communities within the study area depend on hand-dug wells as their major source of water supply. Reports from health centre (Demsa Primary Health Care, 2012), showed rampant cases of water related diseases within the study area. Most of the hand-dug wells have low water table which made it vulnerable to contamination. This study was carried out to determine the bacteriological quality of the hand dug well waters in the area to ascertain the presence of pathogens in the area water sources.

MATERIALS AND METHOD

The Study Area

Demas Local Government area is located at the confluence of River Benue and River Gongola which is on latitude 90^{o} 13'N and longitude 12^{o}37'E in the savannah ecological zone of Nigeria. The boundaries of the area is defined by Yola North and Yola South Local Government areas in the East, Shelleng in the North, Numan in the West and Mayo-Belwa Local Government area in the South. The Climate of the area is divided into two main seasons which are the dry season (November to March) and wet season (April to October). Most of the inhabitants are farmers growing varieties of crops in the areas which include maize, cotton, guinea corn and millet.

Collection of Samples

Water samples were collected from hand dug wells used as water sources for domestic use by the inhabitants in Demsa Local Government area. Three areas were identied for sample collection which includes; Farai, Borrong and Dong. From each location, four sampes were collected, designated as W_1, W_2, W_3 and W_4. A total of 12 samples were collected on each day at an intervals of 7days for 42days. The water samples were collected in 2 litres containers after being sterilized with 70 % (v/v) ethanol. After collecting the samples the containers were closed to avoid escape of gases. Water samples were taken to the laboratory for bacteriological analysis.

Determination of Total Coliform and Faecal Coliform Count

(i) Presumptive test

Colifrm count was obtained using the three tube assay of the Most Probable Number (MPN) technique (Speck, 1976, Manjula et al, 2011 and WHO,2012). Presumptive coliform test was performed using MacConkey broth(Oxoid). The first set of three tubes had sterile 10 ml double strength broth and the second and the third sets had 10 ml single strength broth.All the tubes contained Durham tubes before sterilization. The three sets of tubes received 10 ml, 1 ml and 0.1 ml quantities of water samples using sterile pipettes. The tubes were incubated at 37^{0}C for 24-48hrs for estimation of total coliforms and at 44.5^{0}C for faecal coliforms for 24-48hrs and examined for acid and gas production. Acid production was determined by colour change of the broth from redish purple to yellow, while gas production was checked for by entrapment of gas in the Durham tube. The MPN was then estimated from table for three tube test.

(ii) Confirmed test

Confirm test was carried out in line with (Manjula et al., 2011 and WHO,2012) by transferring a loopful of culture from a positve tube from the presumptive test into a tube of Brilliant Green Lactose Bile (BGLB) broth (Oxoid) with Durham tubes. The tubes were incubated at 37^0C for 24-48hrs for total coliforms and 44.5^0C for 24-48hrs for faecal coliforms and observed for gas production.

(iii) Completed test

Completed test was carried out in accordance with (WHO, 2012) by streaking a loopful of broth from a positive tube onto Eosine Methylene Blue (EMB) agar plate for pure colonies . The plates were incubated at 37^0C for 24-48hrs. Colonies developed on EMB agar, were further identified as coliforms or faecal coliforms (*Escherichia coli*) using cultural characteristics, morphology and biochemical tests. For faecal coliforms, colonies with green metallic sheen were Gram stained and the IMVIC test was carried out to identify the colony as E.coli. The MPN per 100 ml water was determined using the completed test.

RESULTS AND DISCUSSION

Table 1 shows the total coliforms obtained from 4 samples of hand dug well water collected from Farai, Borrong and Dong, respectively. Table 1 indicates that for samples collected from wells at Farai, total coliform ranged 8-9, 6-7, 15-18 and 6-8 MPN per 100 ml with mean value of 9, 6, 16 and 7 MPN per 100 ml for Well; W_1, W_2, W_3 and W_4, respectively. For Borrong location, Table 1 revealed that highest total coliform in the range of 189-191 MPN per 100 ml with mean value of 190 MPN per 100 ml as obtained from well W_2. Wells; W_1, W_3 and W_4 had total coliform in the range of 9-10, 3-5 and 6-10 MPN per 100 ml respectively. Table 1 also revealed that total coliform obtained from wells in Dong ranges between 13-16, 10-20, and 5-7 MPN per 100 ml for Well; W_1, W_2, W_3 and W_4, respectively. The relatively high value of coliform count of 190 MPN per 100 ml found in Well (W_2) located in Borrong can be traced to proximity of the well to stagnant water. Statistically, using analysis of variance, it was observed that there was no significant difference between the total coliform counts in all the wells and the locations at 5 % level of significance.

Table 2 shows the faecal coliform count for the area of study. The Table indicates that at Farai, faecal counts ranged from 3-5, 5-9, 3-5 and 2-4 MPN per 100 ml with mean value of 4, 7, 4 and 3 MPN per 100 ml for Wells; W_1, W_2, W_3 and W_4, respectively. From Table 2 for Borrong, the Well (W_2) had the highest faecal count between 90-94 MPN per 100 ml with mean value of 92 MPN per 100 ml. Well; W1, W3 and W4 had faecal counts in the range of 2-4, 6-8 and 3-7 MPN with mean values of 3, 7 and 5 MPN per 100 ml, respectively. Hand dug well water samples collected from Dong showed that faecal coliform counts ranged from 6-8, 3-5, 2-4 and 3-7 MPN per 100 ml with mean values of 7, 4, 3 and 5 MPN per 100 ml for Well; W_1, W_2, W_3 and W_4, respectively. The highest mean faecal coliform value of 92 MPN per 100 ml was in the range of 12.0-189.2 MPN per 100 ml recorded in earlier studies by (Adeoye et al., 2012) for evaluation of water quality standard in Ibadan. Based on analysis of variance, it was observed that there was no significant difference between the faecal coliform counts in the Wells for all the locations at 5 % level of significance.

The results revealed that Wells in Borrong had much higher faecal coliform count mean value of 27 MPN per 100 ml compared to faecal coliform count mean value of 4 MPN per 100 ml for wells in Farai and Dong, respectively. This implies that water from all the hand –dug wells are not fit for drinking without treatment in accordance with World Health Organization (WHO,1986), United State Environmental Protection Agency (USEPA,2001, 2004) and Oxfam (2005). USEPA and WHO standard for faecal coliform in drinking water is zero faecal coliform per 100 ml.

CONCLUSIONS

The presence of high faecal coliform in Well (W_2) in Borrong could be due to proximity of the well to stagnant water located at a distance less than 30 m which is not in line with WHO recommendations. Also, there is need to increase awareness among the people in the study area the danger associated with the use of contaminated water and construction of pit latrine and septic tank near water source. Water from all the hand dug wells should be boiled and filtered before drinking. A regular monitoring of the water quality for improvement not only prevents disease and hazards but also checks the water resources from going further polluted. The bacteriological examination of hand-dug well water is a sensitive method to assess its quality.

REFERENCES

Adeoye, P.A. Dauda, S.M. Musa, J.J. Adebayo, S.E and M.A.Sadeeq (2012) Evaluation of Water Quality Standards and Sanitary Conditions in Moniya Abattoir, Ibadan, Nigeria. Journal of Applied Technology in Sanitation. 2(1):17-22. ISSN 2088-3218

Ibe,S.N. and J.I. Okplenye (2005) Bacteriological Analysis of Borehole Water in Uli, Nigeria. African Journal of Applied Zoology and Environmental Biology. 7:116-119. I

Manjula, A.V., Shankar, G.K., Preeti and M. Sharada (2011) Bacteriological Analysis of Drinking Water Samples. Journal of Bioscience and Technology. 2(1):220-222.

Mustapha, S. and M.I. Yusuf (1999) A text book on Hydrology and Water Resources. Jenas Prints and Publications Company, Abuja. Nigeria.

Okafor, N. (1985) Aquatic and Microbiology. Fourth edition, Dimension Publishers, Enugu, Nigeria

Okpokwasili, G.C. and T.C. Akujobi (1996) Bacteriological Indicators fo Tropical Water Quality. Environ. Toxical Water Quality. 11:77-82

Oxfam (2005) Technical brief: Water quality analysis in emergency situations. 1-8.

Singh, V.P. and S. Neelam, 2011. A Survey Report on Impact of Abattoir Activities and Management on Residential Neighbourhoods." Indian J. Veterinarians, 6(3): 973-978.

Speck, M.I. (1976) Compendium of Methods for the Microbiological Examination of Foods. American Public Health Association, Washington, D.C.

USEPA (2001): Current drinking water standards. United States Environmental Protection Agency, Washington DC.

USEPA (2004): Guidelines for Drinking Water Quality. United States Geological Survey. Journal of Water Resources. 2:10-15.

WHO (1986): International Standards for Drinking Water Quality. World Health rganization, Geneva. 1:99-120

WHO (2012): Guidelines for Standard Operating Procedures for Microbiology: In Bacteriological Examination of Water. World Health Organization Regional Office for South-East Asia

Table 1: Total Coliform Count (MPN per 100 ml)

Well Number	Farai		Borrong		Dong	
	Range	Mean	Range	Mean	Range	Mean
W_1	8-9	9	9-10	10	10-16	13
W_2	6-7	6	189-191	190	10-20	15
W_3	15-18	16	3-5	4	6-8	7
W_4	6-8	7	6-10	8	5-7	6
Mean		**9**		**53**		**10**

Table 2: Faecal Coliform Count (MPN per 100 ml)

Well Number	Farai		Borrong		Dong	
	Range	Mean	Range	Mean	Range	Mean
W_1	3-5	4	2-4	3	6-8	7
W_2	5-9	7	90-94	92	3-5	4
W_3	3-5	4	6-8	7	2-4	3
W_4	2-4	3	3-7	5	3-7	5
Mean		**4**		**27**		**4**

IMPACT OF CLIMATE CHANGE ON AGRICULTURE AND FOOD SECURITY

G. A. Fumen[1]; E. F. Aiyejagbara[1]; S. B. Igboro[2] and Z. D. Osunde[3]

[1]Department of Agricultural Engineering Technology, Samaru College of Agriculture,
Ahmadu Bello University, Zaria.
engrfumen@yahoo.com
[2]Department of Water resources and Environmental Engineering,
Ahmadu Bello University, Zaria.
[3]Department of Agricultural and Bio resources Engineering,
Federal University of Technology, Minna.

ABSTRACT

Climate change has been identified as the most serious environmental threat on the effort of man to fight against hunger, malnutrition, disease and poverty globally, and particularly in Africa. It has significant negative impacts on agricultural production in the developing countries, which indirectly affect the four dimensions of food security, namely: food availability, food accessibility, food utilization and food stability with an inevitable impact on human health, livelihood assets, food production and distribution channels, as well as changing purchasing power and market flows. This paper highlights the impacts of climate change on agriculture and food security; effect of greenhouse gas emissions on global warming; climate change impacts in Nigeria; Climate change mitigation and adaptation; Sustainable agricultural production under climate change and recommendations on Policy options that could help farmers adapt to climate change.

Climate change in the Sub-saharan Africa is associated with more frequent drought and floods, water scarcity, and increased health challenges such as under-nutrition. Two ways to manage the risks posed by climate change are mitigation and adaptation. Global warming is likely to reduce agricultural production in the tropics, where many developing countries are located, as it causes rainfall patterns shift, and extreme events such as droughts, floods, and more frequent forest fires, resulting in poor and unpredictable yields, thereby making farmers more vulnerable, particularly in Africa. Destruction of natural resources which leads to environmental degradation, high temperature, drought and consequently reduced productivity has been identified as one of the major causes of poverty in Nigeria.Mitigation and adaptation are the two ways to manage the risks posed by climate change.Producing more drought-resistant crops would help, as would better management of water resource, more efficient food storage systems, improved processing methods and better pest management, help in increasing agricultural production in Nigeria under climate change.

Keywords: Impact; Climatechange; Agriculture; Food security; Mitigation; Adaptation

1.0 Introduction

Climate change, attributable to the natural climate cycle and human activities, is one of the most serious global environmental human threatswhich is likely to reduce agricultural production in the tropics, where many developing countries are located(Darwin,2001; Enete and Amusa, 2010 and Ziervogel et al. 2006).It has adversely affected agricultural productivity in Africa and consequently affects four dimensions of food security, viz: (i) food availability,(ii) food accessibility,(iii) food utilization and(iv) food systems stability. Climate change has direct or indirect impact on human health, livelihood assets, food production and distribution channels, as well as changing purchasing power and market flows. Available evidence shows that climate change is global, likewise its impacts,but the most adverse effects will be felt mainly by developing countries, especially those in Africa, due to their low level of coping capabilities (Nwafor 2007 and Jagtap, 2007). As the people of Africa strive to overcome poverty and advance economic growth, this phenomenon threatens to deepen vulnerabilities, erode hard-won gains and seriously undermines prospects for development (Zoellick, 2009). However, Wisner *et al* (2004) reports that the vulnerability of agriculture is not determined by the nature and magnitude of environmental stress like climate change per se, but by the combination of the societal capacity to cope with and/or recover from environmental change. While the coping capacity and degree of exposure is related to environmental changes, they are both also related to changes in societal aspects such as land use and cultural practices.Although responsibility for the causes of climate change rests primarily with the developed and industrialized nations, the cost is borne most directly by the poor within the developing countries like Nigeria. This is for a number of reasons, such as(UNFCCC, 2007): (Many of the regions most likely to be adversely affected fall in the developing world; The poor are disproportionately dependent on occupations, such as farming, that are adversely affected by climate change; and : Because the poor have very limited resources, they do not have the ability to adapt to climate change in the way that wealthier households can. There is therefore the need for concerted efforts toward tackling this menace.This paper takes a viewthe impacts of climate change on agriculture and food security, their mitigation and adaptation, in Nigeria.

The greenhouse induced climate change allows solar radiation from the sun to travel through the atmosphere but prevents the reflected heat from escaping back into space as the gases trap and absorb heat energy radiated from Earth to space, thereby warming the atmosphere and consequently causing earth's temperature to rise.Over the past 250 years, deforestation, combustion of fossil fuels, and production of agricultural commodities such as rice and livestock have caused atmospheric concentrations of carbon dioxide (CO2) and other greenhouse gases to rise significantly (Darwin, 2001).Carbon dioxide(CO_2), which represents about 70% of human-induced GHG emissions, is mainly produced by the burning of fossil fuels like petroleum, coal and kerosene and biomass; Nitous oxide(N_2O) which represents about 16% of the emissions is linked to agriculture, deforestation and certain chemical products; Methane(CH_4), representing about 13% of the emissions is mainly generated by agriculture(rice fields, livestock production) while Flourocarbons such as HFC, PFC and SF6, which represent about 2% of the emissions are widely used in refrigerators, aerosols and foam insulation(CTA, 2007).

Increase in greenhouse gas emissions has been associated with an increase in the mean global temperature of 0.3°C-0.6°C since the late 19th century, and has been predicted that by 2100, as energy consumption increases due to population growth and industrialization, greenhouse gas

emissions could cause the mean global temperature rise of about 2^{o}c or more (Wikipedia, 2011; Holms, 2007 and Darwin, 2001). This is likely to affect crops differently from region to region or bring about a drastic overhaul of agricultural practices (IPCC, 2007).

On how fast is climate change occurring, a conference, "Avoiding Dangerous Climate Change," held in 2005, raised concern that climate change is occurring more quickly than previously anticipated. Among the key findings of the conference were (Defra, 2005): (i) future emissions of greenhouse gases will raise temperatures by 1.4^{o}c - 5.8 ^{o}c during this century, change in ocean acidity is likely to reduce the ocean's capacity to absorb CO2 from the atmosphere, thus compounding the effects of climate change, and will affect the entire marine food chain, and large-scale, irreversible system disruption and the destabilization of the Antarctic ice sheets are serious risks: changes to polar ice, glaciers and rainfall regimes have already occurred.

1.2 Climate change on agriculture

Climate change and agriculture are interrelated processes, both of which take place on a global scale(IPCC,2007). Climate change is projected to have significant impacts on conditions affecting agriculture, such as temperature, carbon dioxide, glacial run-off, precipitation and the interaction of these elements(FAO, 2008 and Fraser, 2008).These conditions determine the carrying capacity of the biosphere to produce enough food for the human population and domesticated animals(Fischar et al,2011). As the planet's temperature rises, rainfall patterns shift, and extreme events such as droughts, floods, and forest fires become more frequent (Zoellick 2009), resulting in poor and unpredictable yields, which makes farmers, particularly in Africa, more vulnerable (UNFCCC, 2007). Farmers, who constitute the bulk of the poor in Africa, face prospects of tragic crop failures, reduced agricultural productivity, increased hunger, malnutrition and diseases (Zoellick 2009). It is projected that crop yield in Africa may fall by 10-20% by 2050 or even up to 50% due to climate change (Jones and Thornton, 2002), particularly because African agriculture is predominantly rain-fed and hence basically dependent on the vagaries of weather(Enete and Amusa, 2010).

Favourable effects on crop yield tend to depend to a large extent on realization of the potentially beneficial effects of carbon dioxide on crop growth and increase of efficiency in water use. Decrease in potential yields is likely to be caused by shortening of the growing period, decrease in water availability and poor vernalization. In the long run, climate change could affect agriculture in several ways (Fischar et al., 2011): (i) productivity, in terms of quantity and quality of crops, (ii) agricultural practices, through changes of water use (irrigation) and agricultural inputs such as herbicides, insecticides and fertilizers, (iii)environmental effects, in particular in relation of frequency and intensity of soil drainage (leading to nitrogen leaching),soil erosion, reduction of crop diversity,(iv) rural space, through the loss and gain of cultivated lands, land speculation, land renunciation, and hydraulic amenities. (v) adaptation, organisms may become more or less competitive, as well as humans may develop urgency to develop more competitive organisms, such as flood resistant or salt resistant varieties of rice. In confidence it has been concluded that climate variability and change would severely compromise agricultural production and access to food (IPCC, 2001)

1.3Climate Change on Food Security

Agriculture is important for food security in two ways: it produces the food people eat, and more importantly, it provides the primary source of livelihood for 36 percent of the world's total workforce. In the heavily populated countries of Asia and the Pacific, this share ranges from 40% - 50%, and in sub-saharan Africa, two-thirds of the working population still make their living from agriculture (Enete and Amusa, 2010). If agricultural production in the low-income developing countries of Asia and Africa is adversely affected by climate change, the livelihoods of large numbers of the rural poor will be put at risk and their vulnerability to food insecurity increased(FAO, 2008). Food security has been defined as 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'' (Purchase, 2011 and FAO, 2008). This definition encompasses four key dimensions of food supplies(Purchase, 2011): availability, accessibility, utilizationandstability(FAO, 2008; Rosenzweig and Hillel, 2011and Ajayi, 2009), which are affected by climate change, with an impact on human health, livelihood assets, food production and distribution channels, as well as changingpurchasing power and market flows, as stated earlier stated.A food system is vulnerable when one or more of thefour dimensionsof food security is uncertain and insecure. (FAO, 2008).

1.3 Climate Change effect in Nigeria

One of the major causes of poverty is the destruction of natural resources which leads to environmental degradation, high temperature, drought and consequently reduced productivity. At present, forest covers approximately 400 million ha (about 17% of land area), with an estimated annual deforestation rate of 0.7%. Studies have shown that due to rising population, migration, land hunger, poverty and starvation, decline in Nigeria's forest area is expected to continue (Garba, 2006). Couple with the traditional and predominant method of clearing farm land through bush burning, the use of firewood as cooking energy source has recently gained prominence as a result of the high cost and scarcity of the conventional energy sources (fossil fuels). These activities increase the concentrations of greenhouse gases (GHGs) in the atmosphere which trap and prevent radiated heat energy from escaping into the space, thereby causing global warming which results in climate change and sea level rise (Medugu, 2009).

As global warming accelerates, it is expected that agricultural adaptation to climate change can only be meaningful, if irrigated agriculture gains prominence. Unfortunately, agricultural practice in Nigeria is still predominantly rain-fed and therefore particularly vulnerable to the impacts of climate change (FAO, 2008 and Medugu, 2008). The consequences are that the increasing frequency and severity of droughts are likely to cause: crop failure; high and rising food prices; distress sale of animals; de-capitalization, impoverishment, hunger, and eventually famine. Households will probably try to cope with their cash and food shortage by cutting and selling more firewood thereby exacerbating land degradation and accelerating the onset of desertification, and by moving temporarily or permanently to more favoured area. In line with this projection, it is predicted that Nigeria is one of the countries expected to be most affected by the impacts of climate change through sea level rise along her coast line, intensified desertification, erosion and flooding disasters and general land degradation (Medugu, 2009).

To adapt to climate change, land tenure and fragmentation systems could limit the capacity of farmers. Among most African peoples, farmland, which is usually less than 1 hectare of land per household, is not owned but held in trust by the present generation on behalf of their future descendants. It could be held by individual families, extended families or entire village communities and then fragmented to individual farmers, who only enjoy user rights. Outright purchase of farmland is not common, but rental for a period of time could be possible (Nweke and Enete 1999). This limits the level of individual farmer's investment in the development of a farmland, as the user right could be withdrawn anytime. Also, the fragmented nature of farmland could hamper the farmers' capacity to adopt innovative farming practices that may be necessary for climate change adaptation. Deressa, 2008) Most of the problems encountered by farmers in adaptation to climate change are associated with poverty. This is because poor and hungry farmers would naturally divert their limited farm income towards the basic necessities like feeding and medication rather than ploughing them into climate change adaptation measures.

1.4Climate Change Mitigation and Adaptation

Two ways to manage the risks posed by climate change are mitigation and adaptation (Holms, 2007). Mitigating climate change means reducing greenhouse gasGHGs emissions and sequestering or storing carbon in the short term to slow or reverse the pace of climate change, andadapting to climate impacts to minimize their effects. It implies the human measures, structural and non-structural, undertaken to limit the adverse impacts of climate change by reducing the levels of greenhouse gases in the atmosphere(FAO, 2007).This is accomplished through the development of appropriate technology for reducing emissions and/or capturing them at their source. Examples of mitigation include measures such as energy efficiency, promotion of renewable energy sources, and carbon trading(Masinde, 2011 and CTA, 2007).Adaptation means adjusting in natural or human systems in response to actual orexpected climatic stimuli or their effects, which moderates harm or exploits beneficialopportunities"(FAO, 2008). It describes a set of responses to the actual and potential impacts of climate change to moderate the harm or take advantage of the opportunities that climate change may bring (IPCC,2007).

Attenuating or mitigating global GHG emissions- by cutting energy consumption, using alternative energy sources, improving transport and waste treatment, reducing deforestation – is the first option in the battle to reduce human-induced emissions at source. The second option involves trapping CO_2 in the atmosphere and sequestering it in carbon sinks such as oceans, forests and the soil which alone contains three-time as much carbon as the atmosphere(CTA, 2007).Carbon trading initiatives will offer some hope of improving the livelihoods of African farmers who have first-hand experience of the impact of climate change, with erratic weather patterns which seriously threatens their crop and livestock production. While adopting more sustainable ways of managing land and increasing output(Masinde, 2011), Carbon marketing or carbon trading is a payment used as an incentive to have rural communities conserve their forests and woodlands. It is a payment that the local communities receive in return for the sacrifice they make to forgo the use of their land for several years so that it can sequester carbon. Under this arrangement, smallholder farmers are encouraged to practice agro forestry by planting food crops alongside trees. Farmers in certain areas are also encouraged to surrender at least a portion of their land for tree planting(Masinde, 2011). Farmers will no longer till their fields as they leave the soil permanently covered with mulch or crop residue. In so doing, they prevent carbon dioxide(CO_2) buried in the soil from escaping into the atmosphere. It is for these tones of trapped

CO_2 that the British company is prepared to pay so handsomely, to compensate for the even greater quantities that it produces, over and above its allowance(CTA, 2007).

In the food and agriculture sector, adaptation and mitigation often go hand in hand, so adopting anintegrated strategic approach represents the best way forward.Several funds within the United Nations system finance specific activities aimed atreducing greenhouse gas emissions and increasing resilience to the negative impacts ofclimate change. Because many mitigation actions that would have high payoffs also representgood options for adaptation within the food and agriculture sectors of low-income developingcountries, it may be possible to obtain additional resources from bilateral and multilateral aidagencies, which are becoming increasingly interested in investing development resources inadaptive responses to climate change. The ultimate goal of FAO's climate change work is to inform and promote local dialogueabout what the impacts of climate change are likely to be and what options exist for reducingvulnerability, and to provide local communities with site-specific solutions.

Hailu(2011) observed that adapting to climatic change is a priority for smallholder farmers, but pointed out that while agriculture will have to contribute to mitigation, it cannot be at the expense of adaptation and food security in the ACP countries.Although the entire food system is a source of greenhouse gas emissions, primary production is by far the most important component. Incentives are needed to persuade crop and livestock producers, agro-industries and ecosystem managers to adopt good practices for mitigating climate change. Adaptation will include using crop varieties which can be better cope with climate changes and relying more on harvesting of water during rainy season (CTA, 2011). An initiative "Crops for climate change", to promote research into food crops that can resist Africa's increasingly tough climatic conditions has been launched by the International Treaty on Plant Genetic Resources for Food and Agriculture(ITPGFA). The focus is on developing "varieties of the 64 most important food and forage crops" that can help the small- scale weather climate change.

1.5Sustainable Agricultural Production

Producing more drought-resistant crops would help, as would better management of water resource, more efficient food storage systems, improved processing methods and better pest management, help in increasing agricultural production in Nigeria (Anon, 2011). Farmers can learn and be encouraged to exercise discretion in planting with the arrival of the earliest rains in the season. Water reservoirs can be created in dry areas such as the Sahel. Mixed farming practices can be introduced. Individuals and communities need to adopt behaviours or policies geared at restoring and conserving the environment. Increased self-reliance, avoiding unregulated forest exploitation, planting appropriate tree species, protecting water sheds, using agro forestry and organic farming techniques and maintaining adequate food supplies will lessen the vulnerability of the food supply sector. So, too, will maintaining water levels so that fish can spawn, planting drought-resistant crops, draining wetlands for rice cultivation, and reforming land tenure and land management policies.

At a local level, erecting contour bunds around farmlands as a safeguard against soil erosion and flooding; using organic manure instead of the more preferred chemical fertilizers; establishing wood lots with fast-maturing plant species that yield domestic fuel wood or more technically, adapting the use of bio and solar energy for household energy needs of rural communities ; reducing bush-burning; usingdisease and drought-resistant, early-maturing crop and plant species

(cassava sticks, fruits and nuts); properly preserving seeds and plant seedlings to ensure healthy germination in the succeeding farming season; and disseminating research findings to farmers, would help mitigate the effects of climate change (Anon, 2011). As well, limiting access to eroded and erosion-prone areas, and initiating and stringently enforcing anti-erosion laws will act as human deterrents. Other adaptative measures could include: adopting new farming approaches, such as mushroom farming and planting more fruit tree orchards, using improved varieties; setting up gene banks; identifying and conserving threatened and endangered species of plants and animals in zoological gardens, and raising public awareness on the importance of bio-diversity.But perhaps the most effective method of staving off the negative effects of climate change is educating the public on the menace of land erosion and the public's role in tackling the problem, and educating Nigerians overall on how climate change will affect all of human activity.

Perhaps the biggest obstacle is lack of awareness and knowledge. Nigerians need to be educated and informed about climate change and how it can change our lives drastically.

1.6CONCLUSIONS

Climate change has been identified as the most serious environmental threat on the effort to fight against hunger, malnutrition, disease and poverty in Africa. It has significant impacts on conditions affecting agriculture, thereby affecting four dimensions of food security, namely food availability, food accessibility t, food utility and food supply stability, with an inevitable impact on human health, livelihood assets, food production and distribution channels, as well as changingpurchasing power and market flows.This paper highlights the impacts of climate change on agriculture and food security, effect of greenhouse gas emissions on global warming, mitigation and adaptation and sustainable agricultural production under climate change in Nigeria.Climate change is global,and likewise its impacts, but its most adverse effects are being felt mainly by the developing countries, especially those in Africa, due to their low level of coping capabilities. Global warming is likely to reduce agricultural production in the tropics, where many developing countries are located, as it causes rainfall patterns shift, and extreme events such as droughts, floods, and forest fires become more frequent resulting in poor and unpredictable yields, thereby making farmers more vulnerable, particularly in Africa. Destruction of natural resources which leads to environmental degradation, high temperature, drought and consequently reduced productivity has been identified as one of the major causes of poverty in Nigeria.Mitigation and adaptation are the two ways to manage the risks posed by climate change.Producing more drought-resistant crops would help, as would better management of water resource, more efficient food storage systems, improved processing methods and better pest management, help in increasing agricultural production in Nigeria under climate change.

1.7 RECOMMENDATIONS

1. Agricultural adaptation to climate change should be mainstreamed into government’s poverty alleviation programme.

2. There is a need to radically depart from reliance on rain-fed food production through heavy utilization of irrigation. There is therefore the need for adequate provision of irrigation and drainage infrastructures which could be regarded as crucial for climate change adaptation

3. The Nigerian government should take a bold step to establish better-equipped weather stations as against the scanty and ill-equipped ones we currently existing in the country. With this, accurate weather forecast and predictions will be possible and this will help to prevent weather-related disasters through early warning and effective response/adaptation system.

4. Investment on improved agricultural technology by government and other stakeholders are very necessary for agriculture to be able to cope under climate change.

5.With the increasing rate of erratic rainfall patterns, drought and desertification, drought resistant and short duration high yielding crops should be developed through research efforts and made available to farmers.

6. The high climate variability that characterizes the African continent presupposes that people have developed successful indigenous adaptation strategies. It is therefore advocated that indigenous knowledge and practices should be integrated into formal climate change mitigation and adaptation strategies.

7. There is need for effective capacity building to strengthen the most vulnerable group in agricultural production with requisite knowledge and information necessary for climate change mitigation and adaptation.

8. Desertification and other unhealthy environmental practices must definitely be curtailed if Nigeria must meet the 2015 target of the Millennium Development Goals (MDGs) of fighting hunger and poverty.

9. Farmers should also have regular information on current issues related to climate change and agriculture. This can be achieved through the strengthening of the nation's extension services perhaps by devolving the bulk of the services down to the local councils, which is closer to the farmers, and encouraging farmers to form farmer groups for enhanced capacity through group efforts. This may help them take advantage of the internet.

REFERENCES

Ajayi, S. (2009):Impact of climate change and food security in nigeria.2009 agric show seminar, 13-14th October 2009, Tudun Wada, Karu lga, Nasarawa state.

Anonymous, 2011: Facts on climate in Nigeria. Repercussion for agriculture, food security, land degradation, forestry and biodiversity

http://www.nestinteractive.org/clmate_change_docs/factsheet4pdf.pdf

Asea, G. (2011): Crops for climate change: Drought. Spore. No. 152, Apri-May, 2011, pp. 7. http://spore.cta.int

CTA., 2008: " Climate change strikes us at the core".CTA special issue-August, 2008. Pp. 24.

CTA.,2011:Editorial. Spore. No. 150, Dec. 2010 – Jan. 2011. Pp.3 http://spore.cta.int

Darwin, R. 2001:Climate Change and Food Security. Issues in food security

http: // www. ers. Usda/briefing/Global climate

Defra,2005:http://www.defra.gov.uk/environment/climatechange/internat/dangerous-cc.htm

Deressa, T; Hassan, R.M; Alemu, T; Yesuf, M. and Ringler, C. 2008: Analyzing the Determinants of Farmers' Choice of Adaptation Methods and Perceptions of Climate Change in the Nile Basin of Ethiopia. *International Food Policy Research Institute* (*IFPRI) Discussion Paper No. 00798*. Environment and Production Technology Division, IFPRI, Washington D.C

Enete, **A.A. and T. A.** Amusa, 2010: Challenges of Agricultural Adaptation to Climate Change in Nigeria: a Synthesis from the Literature », *Field Actions Science Reports* [Online], Vol. 4 | 2010, Online since 20 Décember 2010, Connection on 08 October 2011. URL : http://factsreports.revues.org/678

FAO, 2007: A UN Report on Climate Change retrieved 25 June 2007. Archived June 21, 2007 at the Wayback Machine.

FAO ,2008: Hunger on the Rise. *Food and Agriculture Organisation.* Retrieved August 7, 2010 from http://*www.fao.org/newsroom/EN/news/*

Fischer, G., M. Shah and H. van Velthuizen 2002. "Climate Change and Agricultural Vulnerability". International Institute for Applied Systems Analysis. Report prepared under UN Institutional Contract Agreement 1113 for World Summit on Sustainable Development. Laxenburg, Austria

Fraser, E. 2008. "Crop yield and climate change", Retrieved on 14 September 2009

Garba, A. 2006: Alleviating Poverty in Northern Nigeria. Being a Paper Presented at the Annual Convention of Zumunta Association at Minneapolis United State of America from July 28-29, 2006.

Hailu, M. 2011: Editorial. Spore. No. 150, Dec.2010-Jan. 2011, pp. 13. http://spore.cta.int

Holms, J. 2007: The Stern Review on the Economics of Climate Change, HM Treasury. Available at: http://www.hmtreasury. (stern_review_report.cfm)

IPCC., 2001: Climate Change 2001: Impacts, Vulnerability and Adaptation. Contribution of Working Group III to the Third Assessment Report. *Intergovernmental Panel on Climate Change.* Cambridge: Cambridge University Press.

IPCC., 2007: Climate Change 2007: *The Physical Science Basis (Summary for Policy), Intergovernmental Panel on Climate Change.* Cambridge: Cambridge University Press.

Jagtap, S. 2007: Managing vulnerability to extreme weather and climate events: Implications for agriculture and food security in Africa. *Proceedings of the International Conference on Climate*

Change and Economic Sustainability held at Nnamdi Azikiwe University, Enugu, Nigeria. 12-14 June 2007.

Jones, P.G. and Thornton, P.K. 2002: Croppers to livestock keepers: Livelihood transition to 2010 in Africa due to climate change. Global Environmental Change, World Health Organization, Geneva, Switzerland.

Masinde, I. 2011: Atrade-off for farmers. Interview. Spore. No. 152, April- May, 2011, pp. 12. http://spore.cta.int

Medugu, N. I. 2009: Nigeria: Climate Change - A Threat to the Country's Development. http://www.allafrica.com/nigeria/

Nwafor, J. C .2007: Global climate change: The driver of multiple causes of flood intensity in Sub-Saharan Africa. *Paper presented at the International Conference on Climate Change and Economic Sustainabilityheld at Nnamdi Azikiwe University, Enugu,* Nigeria, 12-14 June 2007.

Nweke, F.I. and A.A. Enete 1999: Gender Surprises in Food Production, Processing and Marketing with Emphasis on Cassava in Africa. Collaborative Study of Cassava in Africa (COSCA) Working Paper No. 19. COSCA, IITA, Ibadan, Nigeria

Purchase, J. 2011: Food security and the food value chain: Issues for consideration. DAFF climate change workshop. www.agbiz.co za

Rosenzweig, C. and D. Hillel, 2011: Potential Impacts of Climate Change on Agriculture and Food Supply. Consequences vol. 1, no. 2, summer 95.http://www.gcrio.org/consequences/summer/rosenzweig.htm

UNFCCC., 2007: Climatic Change Impact, Vulnerabilities and Adaptation in Developing Countries UNFCCC Secretariat, Martin-Luther-King-Street 8 53175 Bonn, Germany. http;//www.unfccc.int.

Wisner, B., P. Blaikie, T. Cannon and I. Davis 2004. At risk: natural hazards; people's vulnerability and disasters. 2nd Edition. London: Routledge.

Ziervogel, G. ; A. Oyong; B. Osman; C. Conde; S. Cortes and T. Dowing 2006: Climate variability and change: implications for household food security. Assessments of Impacts and Adaptations to Climate Change (AIACC) Working Paper No. 20, January 2006. The AIACC Project Office, International START Secretariat, Washington DC, USA.

Zoellick, R. B. 2009: A climate smart future. The nations news papers. Vintage press limited, Lagos, Nigeria. Pp.18

MANAGING FLOODS IN NSUKKA URBAN WITH CLIMATE CHANGE

G. I. Ezenne, C.C. Mbajiorgu and M. Okechukwu

Department of Agricultural and Bioresources Engineering
Faculty of Engineering

University of Nigeria, Nsukka

ifyglory77@yahoo.com

ABSTRACT

Climate includes patterns of temperature, precipitation, humidity, wind and seasons. "Climate change" affects more than just a change in the weather, it refers to any long-term significant change in the "average weather" that a given region experiences. Research on climate change shows that urban cities especially in developing countries are prone to risks of climate change and the impacts can cause huge economic loss. Among all the impacts of Climate Change, our concern in this study is on floods. Increased storm frequency and intensity related toclimate change are exacerbated by local factors such as thegrowing occupation of floodplains, increased runoff from hardsurfaces, inadequate waste management and silted-up drainage. As cities and towns started growing uncontrollably, the land use pattern changed drastically with more area got impervious due to constructions, carpeted roads etc. Often drainage systems become too small to cope with the increased flows from upstream areas. This impact of climate change needs to be incorporated in hydraulic design of drainage system. From the analyses of rainstorms for the period (1976 - 2005), rainstorms have been heavier in Nsukka in more recent years. The mean annual rainfall for the 20-year period (1976 to 1995) is 1694.72mm and that of 10-year period (1996 to 2005) is 1811.09mm. Hence, there is much difference in mean annual rainfall value in the two periods. This actually shows that rainfall amount is increasing as well as the rainfall intensity. As water is a long-term and complicated issue and urban water system planning usually precede other issues, a comprehensive strategy should be taken to management urban flood in Nsukka. The following management strategies are proposed: practice and promotion of integrated flood management; improve capacity of flood detention, storage and drainage in city; implement comprehensive flood management by combining flood management, water resource management, and environmental management; develop system of handling emergent urban water disaster and prepare emergency plan; regional and catchment flood control system should be established to uplift urban flood control capacity; preserve, upgrade and increase monitoring, data analysis and management; identify and fund focused climate change impacts and adaptation research and analysis. Successful implementation of these proposed management strategies will reduce significantly the challenges we face in the longer term.

1.0 Introduction

Climate change is a reality now. It brings with it changes in weather patterns that can have serious repercussions for all of us, upsetting seasonal cycles, harming ecosystems and water supply, affecting agriculture and food production, causing sea-levels to rise. According to Adejuwon (2007), climate change means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in

addition to natural climate variability observed over comparable time periods. The impact of climate change includes floods, landslides, drought and famine. As weather becomes fiercer and storms increase in frequency and intensity, serious socio-economic consequences result. Climate change has a cumulative effect on natural resources and the balance of nature. Table 1 below shows some likely impacts of climate change. The United Nations' Intergovernmental Panel on Climate Change (IPCC) demonstrates in the Fourth Assessment Report of 2007 that, as global temperatures rise, several effects could be more frequent, such as extreme weather events and droughts, rapid sea level rise, breakdown of the marine food chain and worst of all, feedback effects like large releases of methane from thawing permafrost, or large scale dieback of forests (Helmut Breitmeier et al., 2009).Research on climate change shows that urban cities are prone to risks of climate change. They have also an increased responsibility for developing policies for the reduction of greenhouse gas (GHG) emissions (mitigation). According Helmut Breitmeier et al. (2009), the Climate Change Working Group of the UNEP Finance Initiative (CCWG) said that the impacts of climate change cause huge economic costs and are worse in developing countries, where capacities to manage disasters are lower.

Increased storm frequency and intensity related toclimate change are exacerbated by such local factors as thegrowing occupation of floodplains, increased runoff from hardsurfaces, inadequate waste management and silted-up drainage.One can distinguish four types of flooding in urban areas: localizedflooding due to inadequate drainage; flooding from small streamswithin the built-up area; flooding from major rivers; and coastalflooding (Ian Douglas et al., 2008). Etuonovbe (2009), says that urban flooding occur in towns located on flat or low lying terrain especially where little or no provision has been made for surface drainage, or where existing drainage has been blocked with municipal waste, refuse and eroded soil sediments. According to Adelekan (2009), Action Aid (2006) said that Flooding has been identified as one of the major factors that prevents Africa's growing population of city dwellers from escaping poverty and stands in the way of United Nations 2020 goal of achieving significant improvement in the lives of urban slum dwellers. Increased flooding could bring both opportunities and threats for the environment. Majority of African cities lack the infrastructures to withstand extreme weather conditions. Poor urban planning together with other urban governance challenges contributes to making African urban especially Nigerian urban slum dwellers most at risk. Flooding in urban areas is not just related to heavy rainfall and extreme climatic events; it is also related to changes in the built-up areas themselves. Urbanization aggravates flooding by restricting where floods waters can go, by covering large parts of the ground with roofs, roads and pavements, by obstructing sections of natural channels, and by building drains that ensure that water moves to rivers more rapidly than it did under natural conditions. Although the risks faced by urban populations to climate change impacts especially in developing societies has been acknowledged in various regional assessments, their vulnerability cannot be reliably estimated without a detailed knowledge of local contexts since vulnerabilities are so specific to each location and societal context (Adelekan, 2009).

Table 1: Some likely impacts of climate change

Change	Impact on natural systems, agri-culture, water	Impact on urban areas	Impact on health and household coping	Implications for children
Warm spells and heat waves: frequency up on most land areas	Reduced crop yields in warmer regions; wildfire risk up; wider range for disease vectors	Heat islands with higher temperatures (up to 10˚ higher); often large concentrations of vulnerable people; air pollution worse	Increased risk of heat-related mortality and morbidity; more vector-borne disease; impacts for those doing strenuous labour; increased respiratory disease where air pollution worsens; food shortages	Greatest vulnerability to heat stress for young children; high vulnerability to respiratory diseases and vector-borne diseases; highest vulnerability to malnutrition with long-term implications
Heavy precipitation events: frequency up over most areas	Damage to crops; soil erosion; water-logging; water quality problems	Floods and landslide risks up; disruption to livelihoods and city economies; damage to homes, possessions, businesses and to transport and infra-structure; loss of income and assets; often large displacements of population, with risks to social networks and assets	Deaths, injuries, increased food-borne, water-borne and water-washed diseases; more malaria from standing water; decreased mobility with implications for livelihoods; dis-locations; food shortages; risks to mental health, especially associated with displacement	Higher risk of death and injury than adults; more vulnerable to water-borne/water-washed illness and to malaria; risk of acute malnutrition; reduced options for play and social interaction; likelihood of being removed from school /put into work as income is lost; higher risk of neglect, abuse and maltreatment associated with household stress and/or displacement; long-term risks for development and future prospects
Intense tropical cyclone: activity increases	Damage to crops, trees and coral reefs; disruption to water supplies			
Increased area affected by **drought**	Land degradation; lower crop yields; livestock deaths, wildfire risks and water stress up	Water shortages; distress migration into urban centres; hydro-electric constraints; lower rural demand for goods/services; higher food prices	Increased food and water shortages; malnutrition and food- and water-borne diseases up; risk of mental health problems up; respiratory problems from wildfires	Young children at highest health risk from inadequate water supplies; at highest risk of malnutrition, with long-term implications for overall development; risk of early entry into work and exploitation
Increased incidence of **extreme high sea level**	Salinization of water sources	Loss of property and enterprises; damage to tourism; damage to buildings from rising water table	Coastal flooding, increasing risk of death and injuries; loss of livelihoods; health problems from salinated water	Highest rates of death for children; highest health risks from salinization of water supplies; long-term developmental implications

Source: SheridanBartlett, (2008).

High intensity rainfall and floods are more frequent occurrences in most cities and urban areas in recent years. The main reason is human intervention. As cities and towns grow uncontrollably, land-use pattern changes drastically with more impervious land areas due to construction work. Often bridges and culverts become too small to cope with the increased flows from upstream areas, where new urban developments increase the impermeable area. This results in change of

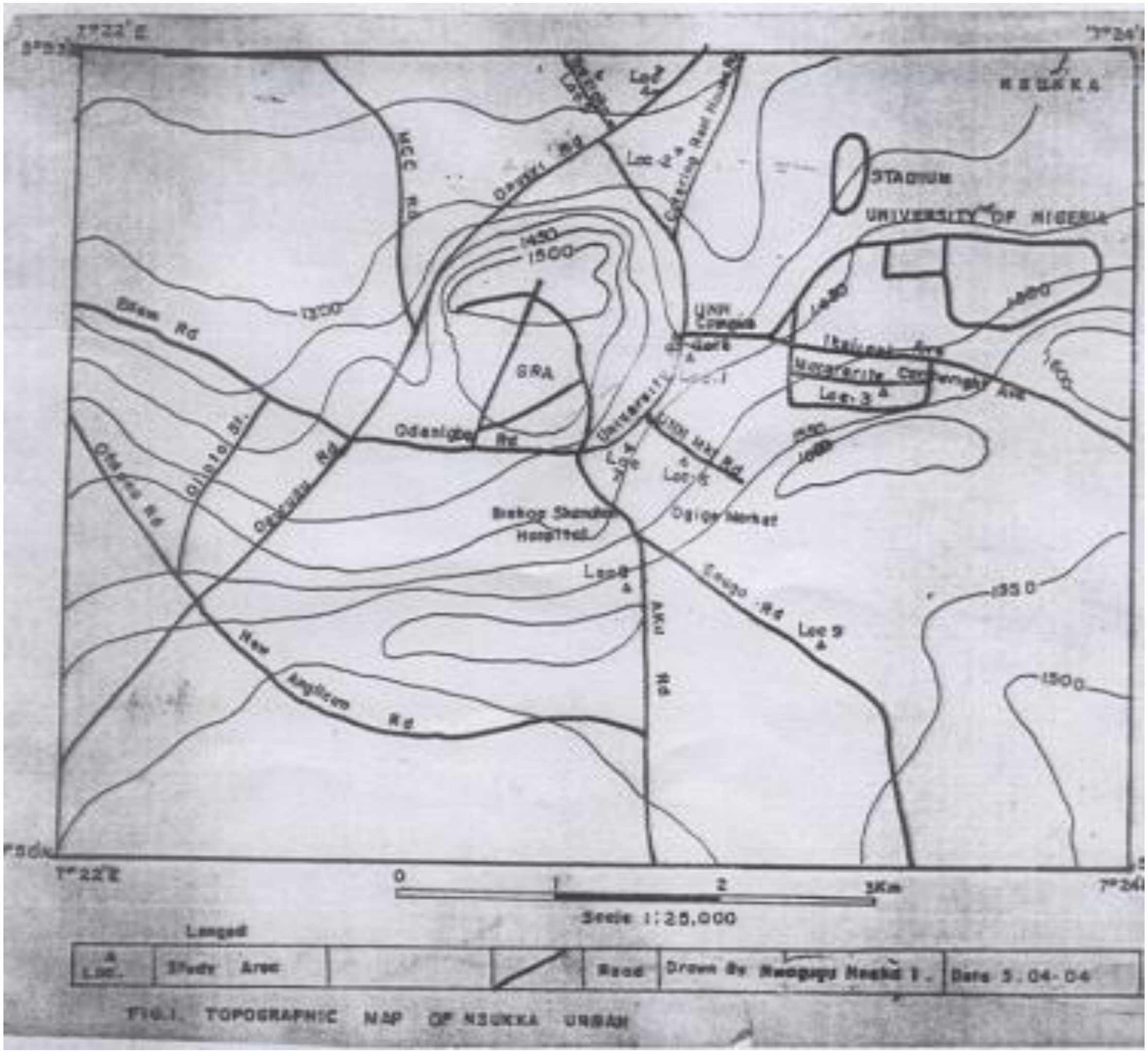
urban hydrology from gradual rising discharge to quicker and higher peak flow (Apte, 2009). According to Action Aid International (2007); Akintola (1994), Oriola (1994) and Babatolu (1997) said that in Nigeria, several studies of the hydrological changes associated with urbanisation have described the contribution of topographic conditions, rainfall characteristics, land use changes (especially the expansion of paved impermeable areas), uncontrolled waste dumping and construction on the flood plain, to local flooding. Poor urban planning or lack of planning as urban development increases is evident in not preventing new development on areas at risk of flooding, leaving unprotected areas that should be left undeveloped, for instance wetlands, because of their role as buffers against flooding risks and also not providing safer sites for the urban poor. Problem is aggravated due to old drainage system designed as per benefit cost ratio prevalent at that time which in many cases now inadequate with enhanced socio economical activities with decreased affordable risk of failure. The existing drainage systems are not maintained properly due to financial constraints. Drainage system gets blocked due to silting, dumping of waste material at the inlets of drains, encroachment over natural drainages, water bodies and so on. The sharp peak discharge of flood hydrograph due to intense rainfall many a time crosses the drainage capacity of the system resulting in stagnation of water on roads and open areas resulting in urban flood.

Problem of urban floods will get aggravated in future as climate models are projecting increase in rainfall with decrease in rainy days that is increase in high intensity rainfall events, resulting in further rise in peak discharge in many countries. This impact of climate change needs to be incorporated in hydraulic design of drainage system.

Increase in urbanization, number of heavy rainfall days and also rainfall intensity will result into change in urban run of hydrograph with steep rise and higher peak discharge. If the runoff can be retained temporarily and released slowly, runoff time can be increased with decrease in peak discharge (Apte, 2009). This study tries to analyze ways of managing urban floods in Nsukka town in the face of climate change. Our people are yet to be fully aware of effects of climate change. Ironically, it is the developing countries like Nigeria who are the most vulnerable to its effects. As Nigerians especially Nsukka urban dwellers, we need to understand how we, personally, help to exacerbate Climate Change, and how we can adapt to it.

2. Nsukka Urban

Nsukka is located on longitude $7^0$22'E and latitude $5^0$50'N in the South Eastern part of Nigeria. It is in the humid tropical climatic region and is characterized by two distinct seasons (wet and dry season). The wet season occurs mainly between April and October while the dry season is experienced during the remaining months of the year (November to March). During the rainy season many parts of Nsukka urban are susceptible to flooding. Figure 1 shows the topographic map of Nsukka urban. The topographic characteristic of the area is fold hilly with steep slopes in many places. During rainy season, heavy rainfall results in high amount of runoff, which quickly generates and flows down the hills via the steep slopes with high velocity (Nwagugu and Mbajiorgu, 2008). This often results in flooding of roads, residential and business areas as well as farmlands located down the slopes.



Source: Nwagugu and Mbajiorgu (2008)

Figure 1: Topographic map of Nsukka Urban

Major causes of floods in Nsukka urban are as follows:

i. Poor urban planning or lack of planning as urban development increases
ii. Uncontrolled waste dumping
iii. Construction on the flood plain
iv. Old drainage system
v. Inadequate maintenance culture
vi. Absence of drainage facilities in most places around the town, which results in a very poor drainage of the urban areas.
vii. Weak institutional capacity of the urban administration
viii. Topography and changes in the intensity and pattern of storms is also a factor

Appendix I shows pictures of some sites affected by floods in Nsukka urban area. Catering Rest house is situated at location 2 in Figure 1. The area is on a contour of 1300 feet above sea level, down a gentle slope, which ends up in a valley.This area especially the roads have fundamental

drainage problems; such as lack of side drains and of course there is no evidence of any existing central drainage system where all the runoff and flood waters could drain to after heavy rainfall event. The ponded flood waters (see plate Ia) cut through the soil along and across roads forming gullies and frequently rendering the road unmotorable with a lot of debris deposited after heavy rainfall events. Also affected by flood is Onuiyi area which is at location 4 on figure 1 and on a contour of 1300 feet above sea level. According to Nwagugu and Mbajiorgu (2008), at the time of their study, after-rain events including heavy runoff and flooding cause serious damages on roads and residential houses (plate Ib). And waste disposal methods of people living in the area is worsening the situation, this often block and impair the constructed and natural drainage facilities.

Analyses of rainstorms in Nsukka for the period (1976 - 2005) show that in more recent years rainstorms have been heavier. Figure 2 shows the mean rainfall amount (mm) for Nsukka between1976 to 2005. A comparison of rainfall characteristics for the two periods 1976-1995 and 1996-2005 was carried out. We found that the mean annual rainfall for the 20-year period (1976 to 1995) is 1694.72mm and that of 10year period (1996 to 2005) is 1811.09mm. There is much difference in mean annual rainfall value in the two periods. This actually shows that rainfall amount is increasing as well as the rainfall intensity. With this, there is no doubt that Nsukka urban is also experiencing the impact of climate change.

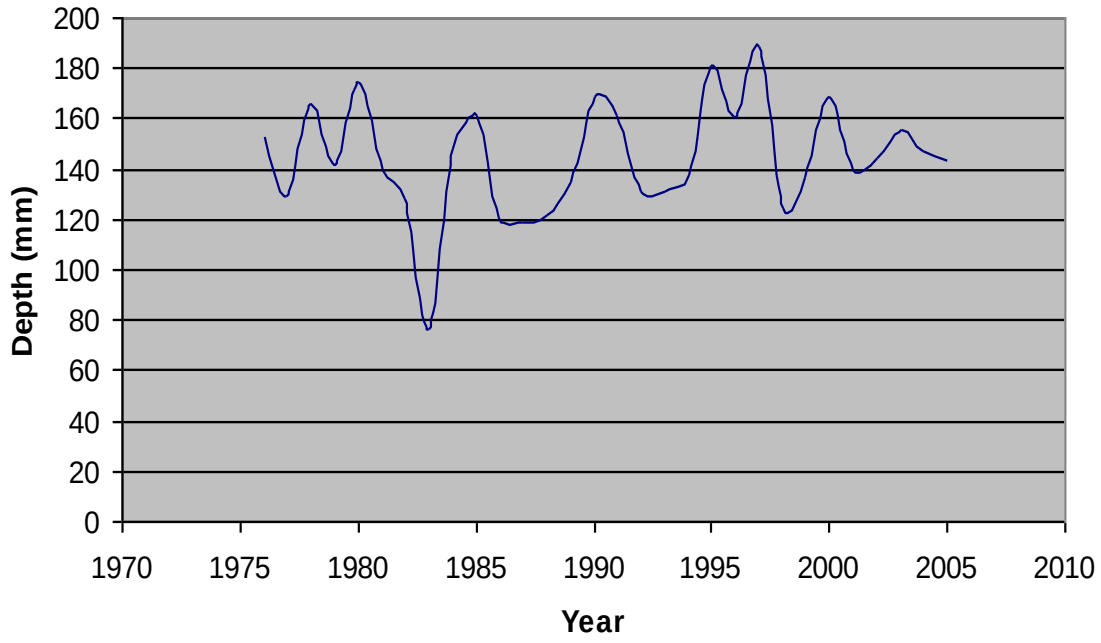


Figure 2: Mean monthly rainfall amount (mm) for Nsukka (1976-2005)

3. Nsukka Urban Flood Management Strategy

Rapid urbanization has resulted in water supply shortage, deteriorating water environment and escalated water disasters. Water problem is even evolving into water crisis in some places, and getting worse. As water is a long-term and complicated issue and urban water system planning usually precede other issues, a comprehensive strategy should be taken to management urban flood, which is to combine strategies for flood risk and hazard mitigation, urban development,

and countermeasures coping with climate change.

(a) Practice and Promotion of Integrated Flood Management

The approach to flood risk management should shift from a reliance on flood defences to a holistic management of risk, combining defence and measures to alleviate the impact of floods. Flood risk measures should include both active measures, passive measures and emergency management measures(Michael Pitt, 2007). Urban areas should be designed to provide adequate surface pathways to convey excess flow safely during extreme events. This includes the need to make adequate space between buildings and to design roads, open space and pathways to act as flood conveyance channels. Climate change will increase the urban's flood risk by causing a shift toward more intense storms which could produce higher peak flows. Flood systems throughout the Nsukka urban must be upgraded and managed to accommodate the higher variability of flood flows, to protect public safety, the economy and ecosystems. Flood management systems must better utilize natural floodplain processes. According to California Department of Water Resources (2008), flood management should be integrated with watershed management on open space, agricultural, and other low density lands to lessen flood peaks, reduce sedimentation, temporarily store floodwaters and recharge aquifers, and restore environmental flows. Government should implement land use policies that decrease flood risk. Climate change and change of land-use are gradual processes that require slow but continuous adaptation (Liu Zhiyu, 2009). Due to the uncertainties we face, it is, therefore, prudent in long-term urban planning to adopt and use a precautionary approach, considering the long-term benefits and consequences of flood management strategies and actions: environmental and social impact assessment, cost-benefit analysis, life-cycle costs, and risk analysis should be factored into the decision making process to ensure the economic, societal and environmental costs and uncertainties are considered and well balanced. Long-term urban planning calls for an integrated, area-oriented approach: such integration requires that planners, water managers and designers adopt a system approach. This approach addresses resiliency as an ongoing goal in every aspect of urban planning and urban system investment.

(b) Improve capacity of flood detention, storage and drainage in city

A variety of measures should be taken to expand storm water detention and storage capacity, which not only mitigates loss caused by flood and water-logging, but also provides a chance for groundwater replenishment. Surface and groundwater resources must be managed conjunctively to meet the challenges posed by climate change. Additional water storage and conveyance improvements are necessary to provide flexibility to facilitate water transfers between regions and to provide better flood management, water quality and system reliability, in response to daily and seasonal variations and uncertainties in water supply and use. Better management of surface storage reservoirs can also provide benefits in a changing climate. Depending on the size and management of storage reservoir the benefits include capturing higher peak flows, providing cold water releases for fish, drinking water, and generating clean hydroelectricity. Laws can be established to improve storm water infiltration and detention measures, and require that all new and renovated communities build storm water modulation pond of appropriate volume. By such means, rain water stored in such pond can be discharged into rivers after the flood peak passes or used for vegetation irrigation and city cleaning.

(c) **Implement comprehensive flood management by combining flood management, water resource management, and environmental management.** Under the prerequisite of flood control safety, comprehensive water management plan should consider efficient use of city water resource and improvement of city environment as well as cityscape. In addition, specific rules are prepared to guide house construction in areas prone to flooding, such as detailed requirements for ground elevation, development density, materials, pipeline network, electricity planning, door and window sealing, parking space and entry and exit. State governments can try to avert future floods if they begin the process of identifying all waterways in the Nsukka urban and clear them of all built-up structures in order to avoid the flood disaster. Municipal authorities must also ensure that property developers adhere strictly to building codes, which should now be updated and brought in line with new environmental trends (Daily Trust, 7th September, 2009). Municipal authorities should construct culverts, drainage channels (especially areas that have none) and storm drains in the Nsukka urban, and provide an efficient refuse disposal system that would lessen the tendency among residents to dump domestic waste in water passages, thereby blocking them. Some individuals should be appointed to assist municipal authorities propagate information about the need to keep drainages provided in the environment free of dumps that might clog the waterways and cause flooding during the rains. Where municipal authorities determine that a structure is not in accordance with the building code, or is erected on a waterway, and marked 'X' to indicate so, it should be pulled down immediately. The authorities must punish their officials who compromise approved building codes for gratification, and putting the lives of other people in peril in the process.

(d) Develop system of handling emergent urban water disaster and prepare emergency plan

Emergency plan needs to be established to handle flood in this era of climate change and the plan must be practical and operable. Latest technology should be used for prediction

accuracy; advanced equipment is also necessary to give alert earlier; alert levels should be standardized; efforts should be taken to publicize emergency plan so that the public know everything for survival in such case. As a huge amount of manpower, materials and money are needed in short term of an emergency, legislative regulations should be established to determine responsibilities and obligations of related departments, a coordination system and the procedure to start up the emergency plan.

(e) Regional and catchment flood control system should be established to uplift urban flood control capacity

To uplift urban flood control and drainage standards and capacity, existing engineering are checked or strengthened to eliminate potential risks and new engineering construction is expedited. Investment can be from state and local government, revenues from service fee for water way engineering construction management, urban water foundation, bank loans, and land development.

(f) Preserve, Upgrade and Increase Monitoring, Data Analysis and Management

Uncertainty in the rate and magnitude of long-term climate change must be reduced. As one example, there are currently inadequate hydrologic observational network (e.g. rain gauges) in Nsukka which makes it most vulnerable to climate change. This GIS-based system will include

different aspects in the decision-making process, including information collection and processing, storm monitoring and early warning, flood prediction, disaster prediction and statistics, economic loss evaluation, risky areas identification, emergency command, information release, etc. The urban water disaster evaluation is to inform the public in the form of diagram so that people can take preventive measures and necessary survival measures in case of an emergent flood. Improved data analysis, and interpretation supported by a robust monitoring network can help identify trends, provide for better real-time system management, and evaluate and, correct, adaptation strategies.

(g) Identify and Fund Focused Climate Change Impacts and Adaptation Research and Analysis

Developing more focused research can help narrow the range of uncertainty in climate change, with a concentration on the vulnerability of water and other natural resources. Such research should include disaster evolution study, study and utilization of advanced technologies such as remote measuring, communication, information management, flood control decision-making, risk analysis, flood control, prediction, hydrological calculation, and ecological treatment, urban hydrology tasks (monitoring station network establishment, early stage alert prediction etc.), disaster compensation policy, and flood control standard identification. This research will assist in planning for new projects, management activities and policies. Our government also needs to demonstrate its concern about Climate Change and how it will affect all Nigerians and the Nigerian ecosystem. The Nigerian government must adopt strategies and policies to fund research on Climate Change.

4. CONCLUSION

Some of the destruction caused by floods in urban areas could have been avoided or its effects mitigated if proper environmental rules had been observed. Usually, areas prone to such flooding are blocked drainages and waterways, and absence of proper drainage system. Sometimes, people ignore the dangers inherent in building structures in flood prone areas. Urban flooding is becoming an inevitable risk in cities, and it is getting more complex following the interaction of more human activities and extreme climate events. We must face it squarely and change our understanding about it and philosophy for handling it so that better approaches and ideas can be found to ultimately achieve harmony between human being and the nature. Therefore, policy and technical solution should be specific to case, which should respect local conditions and socio-economic development law of the place. Shift from flood control to flood management depends on structural measures, societal management level, science and technology advance, people's awareness, as well as behavior mode. Successful management of climate change will reduce significantly the challenges we face in the longer term.

5. REFERENCE

Action Aid (2006). Climate change, urban flooding and the rights of the urban poor in Africa. A report by Action Aid International

ActionAid International (2007). Unjust waters - Climate change, flooding and the protection of poor urban communities: experiences from six African cities. Pp 10- 12 www.actionaid.org

Adejuwon Jare (2007). Environment and Impacts of Climate Change. Paper Presented at Leadership in Environment and Development (lead) Training Programme, Yaba, Lagos

Adelekan Ibidun O. (2009) Vulnerability of Poor Urban Coastal Communities to

Climate Change in Lagos, Nigeria. Fifth Urban Research Symposium.

Akintola F. (1994). Flooding phenomenon, In: Filani et al (Eds) Ibadan Region. Rex Charles Publication in Association with Connel Publications, Ibadan, Pp. 244–255

Apte N. Y. (2009). Urban Floods in context of India. India Meteorological Department, New Delhi (INDIA). Pp. 1-20.

Babatolu J. (1997). The June 24th 1995 flood in Ondo: its antecedents and incidents, Ife Research Publication in Geography 6, Pp. 158–164

California Department of Water Resources (2008) Managing An Uncertain

Future : Climate Change Adaptation Strategies for California's Water.

www.climatechange.water.ca.gov. Pp. 16-27

Climate Change Working Group of the UNEP Finance Initiative (CCWG) (2006). Adaptation and Vulnerability to Climate Change: The Role of the Finance Sector, CEO Briefing,http://www.unepfi.org/fileadmin/documents/CEO_briefing_adaptation_vulnerability_2006.pdf.

Daily Trust, 7th September (2009). Nigeria: Managing Flood Disasters. AllAfrica Global Media (allAfrica.com).

Etuonovbe A. K(2009). The Devastating Effects of Environmental Degradation- A Case Study of the Niger Delta Region of Nigeria. TS 1D – Environment and Land Use Planning ,Surveyors Key Role in Accelerated Development Eilat, Israel

Helmut Breitmeier, Judith Kuhn and Sandra Schwindenhammer (2009). Analyzing Urban Adaptation Strategies to Climate Change: A Comparison of the Coastal Cities of Dhaka, Lagos and Hamburg. Contribution to the Panel, Regieren in Klimawandel" Section „Regierungssystem und Regieren in der Bundesrepublik Deutschland", DVPW-Kongress. Pp 8-12

Ian Douglas , Kurshid Alam, Maryanne Maghenda , Yasmin Mcdonnell , Louise Mclean , and Jack Campbell (2008).Unjust waters: climate change, flooding and the urban poor in Africa. Environment and Urbanization, Vol. 20, No. 1, Pp. 187-205

Liu Zhiyu (2009). Strategies and Countermeasures for Integrated
Urban Flood Management in China. Bureau of Hydrology, Ministry of Water Resources, China. Pp. 6 -8

Michael Pitt (2007). Joint Policy Statement on Managing Urban Flood Risk. Landscape Institute. Pp 5-10

Nwagugu N. I. and C.C. Mbajiorgu (2008). Drainage Problems of Nsukka Urban. Nigeria Institute of Agricultural Engineers Proceedings. Yola, Nigeria. Pp. 235-238

Oriola O. (1994). Strategies for combating urban flooding in a developing nation: a case study from Ondo, The Environmentalist Vol 14, Pp. 57–62

Sheridan Bartlett, (2008). Climate change and urban children: Impacts and implications for adaptation in low- and middle-income countries. Human Settlement Discussion Paper. Theme: Climate Change and Cities-2. International Institute for Environment and Development (IIED). London WC1H 0DD, UK. P. 7

APPENDIX I
Pictures of some sites affected by floods in Nsukka urban area



Plate Ia:Picture showing floods affected site at Catering Rest House Road, Nsukka



Plate Ib:Picture showing floods affected site at Onuiyi Road, Nsukka

VAGARIES OF CLIMATE AND FARMER ADAPTATION FOR SURVIVAL IN THE FADAMA OF BAUCHI STATE, NIGERIA

Ibrahim, A.U[1]. ; Musa, S.M[2] and Mofoke, A. L. E[1].

[1] Agricultural and Bio-Resources Engineering Programme, ATBU, Bauchi, Nigeria.
[2]Rectors Office. Federal Polytechnic, Bauchi

ABSTRACT

The vagary of climate is one of the major concerns of the small scale farmer of the river flood plains (Fadama) in Bauchi State, Nigeria. This natural phenomenal change has continued to pose a threat to attaining food security objective in the State. It is imperative therefore to understand the climatic changes, their impacts on agriculture and the adaptive measures put in place by the farmer for his survival.

This paper has therefore tried to highlight the climatic changes in Bauchi State over 30 years, its' impacts and the adaptive measures practiced by the farmers. Climate change indicators monitored in this study include rainfall, temperature and solar radiation. The study has revealed that, mean annual rainfall had decreased and mean monthly temperature increased by 37-65mm and 0.6-3 ^{o} C respectively over 30 years in the state. The monthly solar radiation was also affected with the decrease in the rain cloud conditions over the years. Also in this paper a number of adaptive measures at farm level have been evaluated and the need to update farmers' strategies is emphasized.

Key words: Climatic vagaries, adaptation, Bauchi State.

1.0 Introduction

Bauchi State lies between latitude 9. 3^{0} and 2.3^{0} North of the equator and longitude 8.5^{0} and 11^{0} **E**ast of Greenwich Meridien. The State is about 300 kilometers south to the enchroaching dunes of the Sahara desert on the North and about 1200 kilometers north of the Atlantic ocean.The State covers a total land area of 49,259.01 sq Km, with a total 181,000 hactares cultivable for dry season irrigation using shallow ground water (Musa et al., 2007). The State is divided in to three agro-vegetation zones on the basis of climate, vegetation and hydrogeology. On the southern fringe is the southern zone that is woody savannah and has mean annual rainfall of about 1000mm ; on the northern end is the northern zone that is grass savannah has mean annual rainfall of about 500mm and a transition zone between the two zones classified here as central zone (ARKA, 1983). Over 60% of the population are rural settlers on the Fadama and mainly practice one or more of the following enterprises:- small scale irrigation-farming, rainfed farming , fishing, hunting, livestock rearing, wood gathering , bee keeping.

Most of the inhabitants along the river systems in Bauchi State have their livelihood depend on the Fadama resources but, over the years (since 1970) these stakeholders have noticed a continuous depletion in the Fadama resources over the years. For instance, the extent of the annual floods have continued to shrink; the reduction in annual run-off and quantity of fertile soil brought to farmers' land by alleviation over time; the reduction in population and species of

plants, fish, migratory birds as noticed by the stakeholders in the Fadama; and the reduction in yield of irrigation tube-wells for low recharge. These tangible changes in the Fadama resources as noticed by the common man was reported by various researchers (IUCN, 1997; Ekpoh,2010). Fadama users therefore need to know the causes and implications of climate change towards a sustainable resources utilisation in the Fadama.

Now, describing the climate in Bauchi State, one would say the climatic characteristic of the State is that of a typical tropical zone. The climate in the area is largely determined by the properties and movement of the Inter-tropical Convergence Zone (ITCZ). The north-ward progression of the sun during the period of March to September from the north of the equator brings rain bearing south westerly winds to the State. Similarly, with the southwards movement of the sun during the periods of October to February, northerly and north-easterly hamattan dry winds blow from the Sahara desert. This phenomenon was also explained by several climatologists (Clackson, 1957; Cocheme and Franquin, 1967).

2.0 Data collection, collation and analysis

The prime source of the climatic data for the period 1949-1961 in this study was obtained from the Nigerian Meteorological Services (NMS) as collated and analysed by Aitchison et al., 1972. Data for 1980 to 1991 extracted from the monthly summaries of the aerodrome located in Bauchi, Agricultural Development Programme (BSADP,1989) annual reports and the report of the Japanese International Cooperation Agency(JICA,1994) as collated by FMWR&RD(1998). Additional data collected from the BSADP for the period 2000 to 2012 from their agro- weather stations across the State were doubtful therefore could not be use for this study. A verification of the mean values for 1980 - 91 as given by the Bauchi aerodrome and the BSADP was carried out by recalculating the mean of the observed monthly values.

3.0 Results and Discussions

The information presented below is the review of the climatic changes in form of rainfall, temperature and sunshine hours for an interval of 30 years (1949- 1961) and (1980-1989) in Bauchi State. The implications on the Fadama farming practices on the climatic changes and the mitigations adopted by the farmers has also been mentioned.

3.1 Rainfall

Table 3.1 Shows the Change in the Mean Monthly rainfall (mm) in 30 years interval (1950s and 1980s) for the three agro-climatic zones of Bauchi State, Nigeria.

Month	Years of Observation 1949 – 1961*			1980-1989**		
	Northern Zone	Central Zone	South-West Zone	Northern Zone	Central Zone	South-West Zone
	Monthly mean rainfall in mm					
Jan	0.0	0.0	0.0	0.0	0.0	0.0
Feb	0.0	0.0	0.0	0.0	0.0	0.0
March	0.2	4.8	5.3	4.0	2.0	5.0

April	8.4	19.3	5.3	11.0	9.0	38.0
May	58.4	99.1	94.7	48.0	37.0	88.0
June	82.3	109.0	146.5	69.0	118.0	145.0
July	184.9	239.5	252.7	134.0	174.0	246.0
August	285.5	362.7	340.9	191.0	262.0	273.0
Sept	116.8	156.2	181.9	84.0	131.0	159.0
Oct	16.2	33.8	34.8	20.0	9.0	28.0
Nov	0.5	0.0	0.8	0.0	0.0	0.0
Dec	0.0	0.0	0.0	0.0	0.0	0.0
Total	753.2	1024.4	1062.9	561.0	742.0	982.0

***Aischison et al. 1972 ** BAUCHI Aerodrome, FMWR&RD 1998**

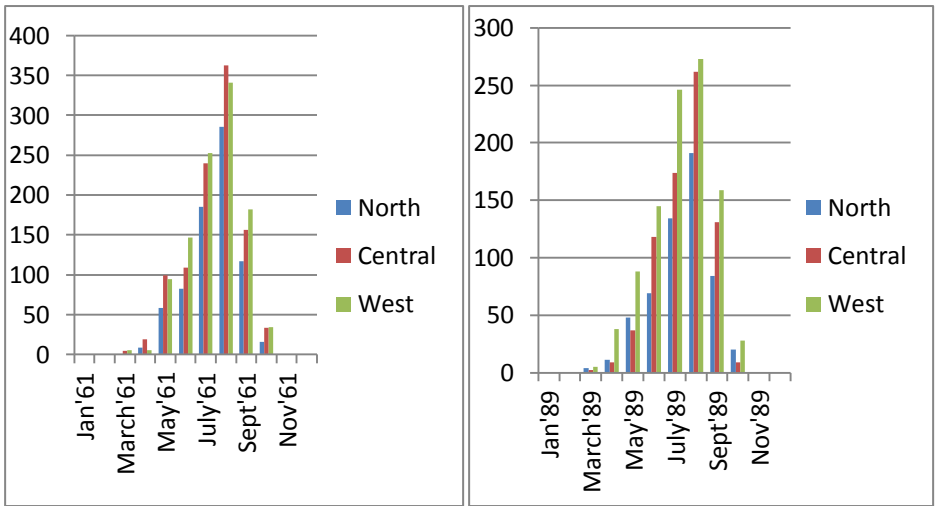


Figure 3.1 Shows the variations in mean monthly rainfall (mm) at 30 years interval (1949-1961) and (1980-89) in the three agro-climatic zones of Bauchi State, Nigeria.

It can be seen from Table 3.1 and Figure 3.1 that the highest rainfall up to 1000mm in Bauchi State is received in Western agro-climatic zone while the lowest 561mm mean annual rainfall is received in the Northern zone. In all cases across the State highest monthly rainfall is received in August, while months of June July, August and September generally, and contribute up to 80% of the annual rainfall. Rainfall ends in November across the state in the 1950s, while in 1980s it ends in October .It was observed that there was drop in the mean monthly rainfall by about 81mm in August,22mm in September, and 6.8mm in October for western zone over the 30 years. The reduction in the mean monthly rainfall is worst in northern zone of the State with up to 94.5mm in august, 35.8mm in September and no rain at all in November after 30 years. The situation in Bauchi State is similar to the one report on the global outlook. Evidence indicating significant change in global climate over the past century has been presented in the Intergovernmental Panel on Climate Change Fourth assessment report (IPCC, 2007). This trend goes along with a recent projection in east Africa which suggest that increasing temperature due to climate change will decrease rainfall by 5-20% from June to August by year 2050 (Hulme, 2001; IPCC, 2007).

An ECOWAS-SWAC/OECD (2008) study has also reported that there has been a substantial reduction in rainfall in West Africa generally over the last 50years with a clear break between

1968 and 1972. The reduction is extremely clear in the Sahel, with high deficit periods in 1972-1973, 1982-84 and 1997. This trend has taken the form of a 200km downward slide in isohyets toward the South. However, it is still uncertain how rainfall will change in the 21cetuary in some parts of Africa (IPCC, 2007). Though a return to better rainfall condition has been noted since the mid 1990s, it is likely that past climate trends may continue, with semi-arid areas becoming more arid (Duryan et al., 2008). This outlook of the past rainfall fluctuations would serve as a pointer to farmers, researchers and policy makers in agricultural and environmental planning. For instance, the onset of the rain season fully starts in late April to early May with traces of rains in March, but the end of the rain season comes in the last week of September for North and Central zones, while in western zone the rain ends in early October in the recent years. Both Figures 3.1 and 3.1b illustrates a steady drop in the annual rainfall received in the three zones over the 1949-61 and 1981-89. This observed steady decline in rainfall necessitates the need for extensive use of water conservation measures by the farmers in the state. The importance of such conservation measures is more pronounced in the central and Northern zones of the state because according to table 3.1 and figure 3.1 these parts of the state have relatively lower rainfall (500-650mm).The Southern zone of Bauchi State on the other hand is more prone to soil erosion due to higher mean annual rainfall (1000-1200mm) and runoff.

3.2 Temperature

Table 3.2 and figure 3.2, show monthly mean maximum temperature variation over the 30 year period in Bauchi State. The monthly maximum temperature rose from 36.1 to 36.7 in April over the 30 years. This shows an increase in the mean temperature by up to 0.6 ^{o}C in the same month after 30 years. The temperature fluctuations pattern in Bauchi State, Nigeria is similar to those in other parts of Africa. For instance, Eriksen et al.,2008 have reported that in the second half of the last century mean annual temperature in Africa rose approximately half a centigrade with some areas(Nile Basin countries increased by 0.2 ^{o}C and 0.3^{o}C per decade) warming faster than others(Rwanda increased by 0.7^{o}C to 0.9^{o}C over 50 years). Another interesting trend is the month wise temperature fluctuation circle in the year. For instance temperature continue to rise from February to April, it then sharply drops in May through September but rise again in October/November and finally drops from December through to February. The gradual heating over 30years in Bauchi State, confirms the findings of some researchers for a more warm spells (days) and fewer cold days across the Africa region as observed by Boko et al., 2007. By and large, there is a prediction by some researchers (Boko et al., 2007) that Africa is likely to warm across all seasons during 21st century. According to them, for a medium scenario, annual mean air temperatures are expected to increase between 3 ^{o}C and 4 ^{o}C by 2099, roughly 1.5 times average global temperature. This situation calls for researchers to look in to the mitigation measures especially the adaptation measures employed by the natives, looking at the trend in Bauchi State and the entire Africa region.

One of the implications of higher room temperature is on perishable crops, especially at the time of post harvest handling and storage. A lot of loses are incurred by the Fadama farmers both during storage and transportation to markets due to higher temperature resulting to loses in income. Higher temperature reduces the shelve life of fruits and vegetables. At the time of harvest in April/May when temperature is high farmers store their onions, tomatoes and pepper on river sand beds under ventilated thatch shades to maintain low storage temperature. Similarly leafy vegetables are stored in wet Jud bags that are sprinkled with water at 3-5 hours interval depending on the prevailing room temperature.

Table 3.2 shows the variation in mean monthly temperature (in degree Celsius) in Bauchi at 30 years interval

Month	Years of Observation		Difference
	Mean monthly maximum temperature(^{o}C) for 1949-1961 *	Mean monthly max. temperature (^{o}C) for 1989 -1992**	
Jan	31.5	30.5	-1.0
Feb	33.5	36.1	+2.6
March	35.7	36.70	+1.0
April	36.1	36.70	+0.6
May	34.0	32.2	-1.8
June	31.1	32.5	+1.4
July	28.6	30.20	+1.6
Aug	27.8	28.7	+0.9
Sept	29.0	32.0	+3.0
Oct	31.7	33.6	+1.8
Nov	32.7	31.4	-1.3
Dec	31.0	29.8	-1.2

Source - * Aischison et al. 1972 ** FMA&WR (1998), Bauchi Aerodrome

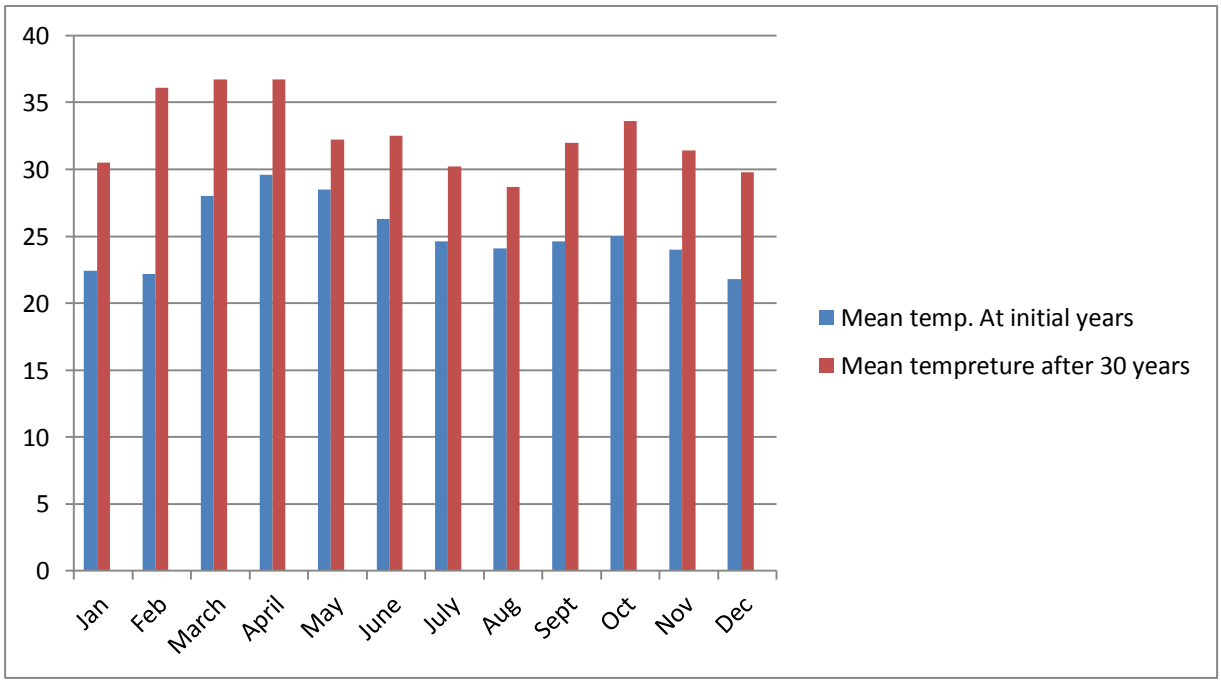


Figure 3.2 Shows the variation in the Mean monthly temperature (^{O}C) at 30 years interval for Western Agro-Climatic zone of Bauchi State

3.4 Sun light Hours

Figure 3.4 and table 3.4shows the monthly variation in the incoming radiation on Bauchi State in 30 years (1949-1961 and 1981-1989). The general picture is that of radiation rising to maximum in November-February and falling to a minimum in August in 1950s. In the 1980s the maximum radiation was in December – February and fall to a minimum still in August. An interesting feature in solar radiation pattern is the marked fall and recovery of the radiation chart in the period February- April for both 1961 and 1991. This could be due to the periodic changes of the ITCZ in the region. As observed by Hamilton and Archbold (1945) there is relationship between the overcast conditions in the sky due to hamattan dust in November - February and the cloud cover during the rain seasons in July -September in the region.

Table 3.4 Shows variation in Monthly Mean Solar radiation in 30 years interval in Bauchi State

Months	Years of Observation		
	1961*	1991**	Difference
Jan	9.08	7.80	-1.28
Feb	9.66	9.00	-0.66
March	8.82	7.50	-1.32
April	7.46	7.30	-0.16
May	8.20	5.90	-2.3
June	7.87	7.20	-0.67
July	6.14	6.30	+0.16
Aug	5.15	5.50	+0.35
Sept	7.34	7.60	+0.26
Oct	8.95	7.60	-1.35
Nov	9.89	7.50	-2.39
Dec	9.72	7.60	-2.12
Total	98.28	86.8	

source– * Aischison et al. 1972, Bauchi aerodrome and FMWR&RD(1998)**

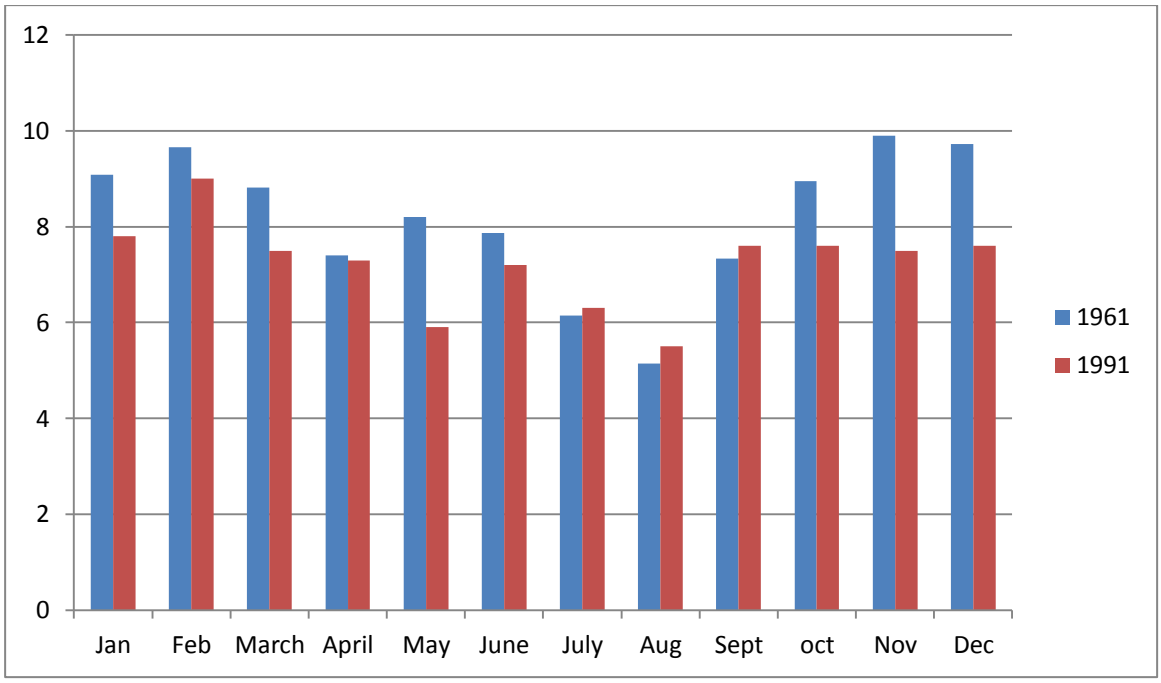


Fig 3.4 Mean hours of bright Sunlight at 30 years interval for Bauchi, Nigeria

4.0 Discussions

Africa is considered the most vulnerable region in the world in terms of climate change because of some of its physical and socio-economic characteristics especially its fragile economy, therefore most affected by adverse effects of climate changes(Niasse et al., 2004). In Bauchi State increasing length of dry season over the years is driving Farmers and herds men to migrate to locations with better moisture conditions and higher soil fertility. This situation seems to be the situation across the sahelian countries of Africa as also reported by Brown and Crawford (2007). The decline in rainfall as reported in this study can be seen in the growth of typha grass and siltation of some lakes as observed in Andiwa, Maladumba, Diya and other lakes across Bauchi State. Decline in rainfall in the region has also resulted in a significant reduction in surface area of Lake Chad, from 20,000km^2 before 1970s to 7,000km^2 after 1970 as reported by Niasse et al., 2004.

The climatic vagaries experienced in Bauchi State over the years illustrate the potential large effects on livestock. One obvious consequence would be rangeland degradation and siltation of lakes which may lead to massive livestock loss as also observed by FAO, 2008b. Some of these impacts of climatic vagaries as observed over time by the Fadama inhabitants provide an insight into how the people adjust to climate change and initiate adaptation measures.

The following are some adaptation and mitigation measures put in place by the Fadama resource users in Bauchi State Nigeria to check the vagaries of climatic changes as observed in this study:

4.1 Moisture conservation by contouring and grass planting

The adaptation and mitigation measures employed by the farmers in Bauchi State include moisture conservation contour ridging and vertiver grass planting. In northern zone Fadama areas where rain is between 500-650mm farmers align their ridges along the farm contour; here the runoff water is slowed down behind the ridges. Not only can it not erode the soil, but also much

more infiltrates so the crop has larger reservoir of water to draw on. In southern zone where mean annual rainfall is higher (1000-1200mm), the build up of water behind the contour ridges can lead to the ridges breaking. The water from behind one ridge flows into the next furrow and breaks the next ridge and so on. This can lead to more severe erosion than before. The farmers in this area therefore align their ridges so that they are at a small angle to the contour such that excess water can run at a safe velocity so that it does not erode the soil in the graded ridge.

In addition to the above practice some farmers plant vertiver grass (vertiver nigritana) on the farm boundries or along the countour rigdes to conserve soil moisture. They do that to encourage sedimentation and deposition by reducing run-off and increase infiltration.

4.2 Soil cooling by Pit hole planting

Planting of seedlings in circular pits about 0.3m deep to retain moisture, reduce soil temperature and evapo-transpiration to encourage sugarcane seedlings speedy growth. This is practiced in northern and central zones of Bauchi State where higher temperature (up to 34^{o}C), hamattan winds and evapo-transpiration are experienced at the time of planting sugarcane seedlings between summer and winter seasons in October-December. This circular pit method is also practiced in some other parts of Africa (Brown and Crawford, 2007; ECOWAS-SWAC/OECD, 2008).

4.3 Barrier against desert encroachment

Other practices include conservation of wetlands that serve as barriers against desert encroachment. A long the borders of Bauchi, Yobe and Jigawa States the Jamaare-Komadugu-Yobe basin serve as barrier to the desert encroaching from the north. Deliberate soil and moisture conservation are practiced by the water resources users in this basin. These measures include; reducing siltation by grass (vertiver) hedge planting on farm boundaries, shelterbelts, runoff dikes. These barriers could also help to filter pollutants and serve as recharge areas to the underground water in the barrier basin (IUCN, 1997).

4.4 Dry planting

At the onset of the rain season, ones first rain shower are received, millet and sorghum are planted in anticipation of the full establishment of the rain as mitigation against dry spell. In northern Bauchi state this is a common practice because ones the rain ends before the crops manure, the farmer has to do supplementary irrigation which add to the production cost to save his crop.

4.5 Thatched Storage shade

Dry season irrigation farmers establish ventilated storage thatch shades and store perishable crops like onions, garlic, and other vegetables in order to extend the shelve life of their produce beyond the high temperature and glut periods to attract higher prices.

4.6 Multiple Cropping Seasons

The mitigation measures by the farmers to overcome the climatic fluctuations include for instance, in Northern zone in the 1950s, rain season takes about 170days ($5^{1}/_{2}$ months) therefore some farmers take advantage and enjoy four cropping seasons (early rainfed in May-August, rain-fed/residual moisture in September -November and irrigated farming in January -March). Later in 1980s when the rain season length dropped to about 140 days ($4^{1}/_{2}$ months), the farmers

have resorted to two cropping seasons with suplimentry irrigation complementing or residual moisture in the event of any dry spells by late September to early October. On the other hand some farmers do resort to early planting after rain showers in April in anticipation of rains that proves to be erratic. Where long dry spell is experienced after the first rain farmers would lose their seeds and have to replant.

4.7Ice block watering

Poultry farmers in Bauchi State provided ice blocks in poultry watering troupes in hotter periods (March- May) to minimise the effect of high temperature on poultry production.

5.0CONCLUSION

This paper has reviewed the climatic changes in Bauchi State over 30 years, its' impacts and the adaptive measures practiced by the farmers. Climate change indicators monitored in this study include rainfall, temperature and solar radiation. It also highlighted the implications experienced by the resources users in the Fadama and the proffered adaptation measures that could help alleviate the effects of climate change elsewhere.

REFERENCES

Aitchison, P.J.; Bawden, M.G.; Carroll, D.M.; Glover, P.E.; klinkenberg, K., de Leeuw, P.N. and Tuley, P. (1972).The Land Resources of North East Nigeria Vol.1 and 5.Study conducted with the assistance of the Overseas Development Administration, U.K.

Boko, M.; Niang,I.; Nyong,A.;Vogel,C.; Githeko,A.;Medany, M.; osman-Elasha; Tabo,R. And Yanda,P. 2007. Africa: Climate Change2007: impact, adaptation and vulnerability. Contribution of Working Group II to the Fourth assessment Report of the International Panel on Climate Change. Parry, M.L.;Canziani, O.F.; Palutikof,J.P. van der Linden,P.J. and Hanson, C.E.(Eds.), Cambridge University Press, Cambridge U.K., 433-467.

Brown,O. And Crawford,A. 2007. Climate Change: A new threat to stability in West Africa? Evidence from Ghana and Burkina Faso. International Institute for Sustainable Development (IISD). Africa security review 17(3): 39-57.

Druyan, L.; Fulakeza, M. And Lonergan, P. 2008. Impact of Vertical resolution on regional model simulation of the West African summer monsoon.Int. J. Climatol28:1293-1314.doi:10.1002/joc.1636.

ECOWAS-SWAC/OECD 2008. Climate and climate change. Atlas on regional Intergration in West Africa. Environment series. ECOWAS-SWAC/OECD.

Erksen,S.; O'Brien, K. And losentrater, L. 2008. Climate change in Eastern and Southern Africa: impacts, Vulnerability and adaptation. Global Environmental Change and Human Security, Report 2008:2.

FAO, 2008. Challeges for Sustainable Land Management (SLM) for Food Security in Africa. 25th Regional Conference for Africa, Nairobi Kenya, Information Paper 5. 55pp

FMWR&RD , 1998. Development of Guidelines for the Sound Management of Surface and Ground Water Resources in the Fadama Areas of Bauchi State. Federal Ministry Of Water Resource and Rural Development (FMWR&RD, Abuja Nigeria.

Himilton,A.T. and Warren, A. (1968). Meteorology of Nigeria and adjuscent territory. Q. Jl R. Met. Soc. 71. 231-264.

Hulme,M. 2001. Climatic perspective on Sahelian desiccation: 1973-1998. Global Environmental Change 11:19-29.

IPCC 2001.Climate change 2001. Synthesis Report. International Panel on Climate Change (ICPC), Cambridge University Press. Cambridge.

IPCC, 2007.Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working GroupII to the Fourth Assessment Report of the International Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, U.K. 976pp.

IUCN, 1997. Water Management Options for the Hadejia-Jamaare-Yobe River Basin, Northern Nigeria.World Conservation Union(IUCN),Hadejia-Nguru Wetlands Conservation Project, Rue Mauverney 28, CH-1196, Switzerland.

JICA, 1994. National Water Resources Master plan Draft Final Report. Voll-IV. Japan International Cooperation Agency, Tokyo Japan.

Musa, S.M.; Mofoke, A.L.E.; Sadiq,A.A.; Ibrahim,A.U. ;Ibrahim,S.; Mohammed, H.A.; Kazaure,Y.D.; Martin,E.M. and Garba, B.(2007). Environmental baseline of Participating Fadama Local Government Areas of Bauchi State. A report submitted to the Bauchi State Fadama II Project, Bauchi State, Nigeria.

Niasse, M.; Afoud,A. and Amani,A.(Eds.) 2004. Reducing West Africa's Vulnerability to climate Impacts on water resources, wetlands and Desertification: Elements of Regional Preparedness and Adaptation. IUCN, Gland, Switzerland and Cambridge, UK. Xviii+66pp.

World Bank 2008. Agriculture for development. World Development Report. The World Bank, Washington, D.C.

WASTEWATER REUSE PRACTICE IN NIGERIA: THE IRRIGATION PERSPECTIVE

Onwuegbunam D.O.[1], Oyebode,M.A.[2], Igbadun,H. E.[2], Onwuegbunam, N.E.[1] and Sobowale, A.[3]

[1]Agricultural Engineering Department, Federal College of Forestry Mechanization, Afaka, Kaduna, Nigeria
[2]Agricultural Engineering Department/Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria
[3]Agricultural Engineering Department, Federal University of Agriculture, Abeokuta, Nigeria.
sobowalea@unaab.edu.ng

ABSTRACT

A review of recent studies on wastewater reuse for irrigation in Nigeria was carried out with a view to determining the present reuse status and challenges. Four studies were examined, three from Northern Nigeria and one from the Southwest. Irrigation water parameters analyzed in the studies and their corresponding range of values are: pH (5.5-7.6), electrical conductivity (0.01-1.52 ds/m), total dissolved solids (5.8-920 mg/l), nitrates (0.3-14.2 mg/l), sulphates (9-16.4 me/l), carbonates (2.1-7.2 me/l), bicarbonates (5.19-11.2 me/l), sodium (0.80-4.1 me/l), calcium (0.86-10.2 me/l), magnesium (0.12-34 me/l), chloride (1.08-40.2 me/l) and boron (0.12-1.1 mg/l). These physicochemical parameters were found to be within the Food and Agriculture Organization limits for irrigation water standards except for calcium in one of the cases. The studies reveal that irrigation with wastewater is being practiced by a few farmers who take advantage of the constant supply nature of wastewater through drainage channels and the high availability of plant nutrients in the wastewaters. There is high potential for wastewater reuse in Nigeria but this is higher in areas that have low annual precipitation, especially, the North. Government involvement in the reuse programme through planning and monitoring would be required because of wastewater potential to affect the soil and the environment adversely over time.

1. INTRODUCTION

Wastewater is a valuable resource in regions where there is water shortage due to aridity. In South Africa for example, water shortage has become a threat as 98% of the country's water resources are already being fully utilized (WASH, 2009).

Growing demand for water for irrigation has increased the need for reuse of wastewater all over the world. Industrial or municipal wastewater reuse in agriculture is a common practice in many parts of the world (WHO, 2006). Scott *et al* (2004) estimated that at least twenty million hectares of land are irrigated with raw or partially treated wastewater. Rising demands for good quality water for domestic and industrial uses in countries with highly developed economies have already created the necessity to reuse wastewater (FAO, 1994). Presently, many developing countries are facing a similar situation, especially in arid and semi-arid regions where limited water quality is already a severe constraint on development (FAO, 1994).

The major reason for wastewater reuse in irrigation according to Horswell *et al* (2003) is that wastewater can be a reliable source of water for irrigation. Also the water has the beneficial

aspect of adding valuable plants nutrients and organic matter to the soil (Horswell *et al*, 2003). Researches have indicated that wastewater contains appreciable concentration of metallic and non-metallic ions, toxic and non-toxic compounds most of which when applied to the soil during irrigation may improve soil nutrients availability (Papadopoulos, 1988). The reuse of sewage effluents for irrigation has been observed to be advantageous as the amount of artificial fertilizer to be applied on farm plots is substantially reduced or eliminated in some cases. In Australia, irrigation of field crops, forests and pastures by effluents have been in practice for years without apparent ill effects and in China, raw sewage has been applied on rice fields and with positive results (Samaila *et al*, 2011). With careful planning and management, the positive aspects of wastewater irrigation can be achieved (WHO, 2006).

Reusing wastewater can remove a potential cause of ground or surface water pollution and at the same time, release higher quality water for other uses. Irrigation represents not only an appropriate disposal medium for many wastes but also an opportunity to manage wastes with minimum adverse environmental effects. When wastewater is used for irrigation, the potential treatment mechanisms are many and these include biological oxidation, ion exchange, chemical precipitation, absorption and assimilation into growing plants and animals (Samaila *et al*, 2011). Wastewater in most Nigerian cities is mainly from three sources namely industrial effluents, agricultural return flows and domestic wastewaters which subsequently find their way into the natural drainage system to raise the quantity of water in receiving surfaces (Samaila *et al*, 2011).

World population increase and the demand for water are of great concern especially in the arid and semi arid regions where the precipitation is low. Hence, conservation of available water resources is essential. Reuse of wastewater is a promising alternative, particularly for irrigation purposes (Arku *et al*, 2012). In these regions the scarcity of freshwater reserve is a critical problem and the temptation to reuse raw water for agriculture is increasing regularly. Wastewater is constant in supply and offers dependable, reliable and consistent source of water for irrigation. For example, it is argued that along the Musi river in Andre Pradesh, India, wastewater contributes to food security by providing water for livelihood activities that is reliable, sufficient and available in demand (Buechler and Devi, 2004). Urban agriculture cannot depend solely on the limiting freshwater resource and calls for the use of wastewater for irrigation (Arku *et al*, 2012).

Many researches have been carried out in the developed countries on effluent water reuse for crop irrigation but such studies are still limited in Africa in general and in Nigeria, in particular (Adewoye *et al*, 2010). The objective of this paper is to examine the wastewater reuse status for crop irrigation in Nigeria with a view to evaluating its potentials and challenges towards increased agricultural productivity.

2. METHODOLOGY

The study evaluates and compares several researches which have been carried out in Nigeria with respect to wastewater reuse for irrigation and its implications on the soil, crop yield and quality, and the environmental impact. Most of the available research works are those carried out in Northern Nigeria, part of which is known to be semi-arid in nature due to its scanty precipitation and low annual rainfall compared to the south. Other researches were those carried out in the south west of Nigeria.

Specifically, based on present studies, the following areas of wastewater reuse are evaluated: motivating factors for reuse, quality issues of wastewater reuse and the future of wastewater reuse in Nigeria

Test parameters obtained from the several researchers are tabulated (Table 3.1) and compared with the existing standard for wastewater reuse for irrigation (Table 3.2).

3. RESULTS AND DISCUSSION

3.1. Motivational factors for wastewater reuse

A major factor considered in the reuse practice is the need to prevent the discharge of wastewater into rivers or streams. Fadeyibi *et al* (20011) observed that wastewater from abattoirs discharged into Sabon Daga River at Minna, Niger State would raise the contamination level and render the river unsafe as a freshwater means for irrigation. He, however, observed from the physicochemical analyses of the wastewater that, except for iron, all the parameters tested are within the threshold levels for irrigation. Adetayo (2012) stated that there is need to continuously monitor and assess the quality of surface water bodies that drain sewage effluents as continued drainage would result to unacceptable water quality of streams and rivers.

3.2. Quality issues of wastewater reuse

Adetayo (2012) showed that concentration of soluble cations and anions of Ona River, South-west Nigeria, viz-a-viz the interacting effect on salinity and toxicity hazard of water are low and within acceptable levels for crop irrigation, during both dry and rainy seasons. There would, however, be need to continuously monitor and assess surface water quality for irrigation purposes.

Arku *et al* (2012) confirmed that raw wastewater discharged from the Nigerian Bottling Company plant in Maiduguri is safe for crop production except that it needs to be monitored periodically to avoid unexpected rise beyond the quality limits. Samaila *et al* (2011), also affirmed this safety limits for the effluents that drain into River Kaduna except for calcium. The excess calcium may serve as a compensating factor in case the sodium level eventually rises beyond normal limits.

Micro irrigation (drip or trickle) systems are known to create the fewest hazards of any kind in terms of microbial contamination of air, soils and plants in the vicinity of the irrigation site. However, the expense of utilizing such systems on a large scale severely limits their feasibility (FAO, 1994). The commonest system adopted by wastewater irrigators has been the surface system, especially the furrow system. Sprinklers are known to create the greatest potential for microbial contamination of the vegetation and air.

3.3. Future of wastewater reuse for irrigation in Nigeria

Presently, water reuse for irrigation is more dominant in the Northern part of Nigeria than the South. One of the major reasons is the apparent scarcity of water resources to meet increasing demand of water for irrigation among other uses.

Agriculture, being a major user of water, especially for irrigation, can accept lower quality water than domestic and industrial users. It is therefore inevitable that there will be a growing tendency to look towards irrigated agriculture for solutions to the overall effluent disposal problem (FAO, 1994).

Studies on the use of partially treat sewage effluents for irrigation in Nigeria are still limited (Adewoye *et al*, 2010). However, the few studies available indicate that with proper monitoring units by extension services wastewater qualities can be conformed to standards recommended for irrigation. What is important now is awareness on the part of the government to adopt wastewater as an important resource to complement the apparently safe water sources. Hence, there would be need to provide secondary and tertiary treatment plants to handle wastewater treatment to the extent that its standard suits all forms of irrigation use.

If water reuse projects are to succeed, efforts to generate greater community awareness to judge water by its quality and not by its history, and seeking their increased particulation in such schemes, will be needed (Vigneswaran and Sundaravadivel, 2004).

4. CONCLUSION AND RECOMMENDATION

In Nigeria wastes are generated from domestic, agricultural and industrial processes. These wastes, whether in liquid or solid forms generate wastewater or effluents that are useful for irrigation purposes as is the common practice in vegetable crops irrigation in many urban parts of Northern Nigeria. The concentration of soluble cations and anions in these wastewaters have been generally found to be within acceptable limits from Food and Agriculture Organization (FAO) standards except that there would be need for continuous monitoring to ensure that threshold limits are not exceeded. Because wastewater contains impurities, careful consideration must be given to the long-term effects on soils and plants due to salinity, sodicity, nutrients and trace elements that occur normally manageable if associated problems with these impurities are understood and allowances made for them

To meet World Health Organization standards for waste water reuse, all levels of treatment – primary, secondary and tertiary – should be put in place and treated effluents used for irrigation of either edible or non-edible crops, depending on the potential health hazard or degree of treatment.

Other potential wastewater resources that need to be explored are those of the aquacultural ponds especially concrete or PVC tank ponds where there is regular need to drain turbid water away in exchange for fresh ones. This would take the form of an integrated farm system whereby, the wastewater is used for irrigation of crops in the same environment as the pond. Also, aquaculture wastewater management could be practiced in the form of aquaponics, which is, the gentle blending of fish farming with hydroponics, soil-less production of crops, especially vegetables. In this practice there would be no chemical or management problem to contend with; waste does not exist in aquaponics system because one portion utilizes the waste from another.

REFERENCES

Adetayo A.O. (2012). Assessment of surface water receiving sewage effluents for gardening irrigation purposes: A case study of Ona river in Ibadan, Southwest Local Government Area, Oyo State, Nigeria. Vol. 1 No. 1, 21-24.

Adewoye A.O., D.A. Okunade and K.O. Adekalu (2010). Assessing the yields and nutrient uptake of okra (*Abelmoschus Esculentu*) using diluted stabilized wastewater for irrigation in Southwestern Nigeria. Journal of wastewater treatment analyses, Vol. 1, Issue 2, 1000104.

Arku A.Y., S.M. Musa, A.L.E. Mofoke and J.M. Dibal (2012). Re-examining raw effluents from Nigerian Bottling Company, Maiduguri for crop irrigation. Journal of Applied hytotechnology in environmental sanitation, 1(1): 43-49

Buechler S. and G. Devi (2004). Household food security and wastewater – dependent livelihood activities along the Musi River in Andre Pradesh, India. International water management institute (IWMI). http://publications.iwmi.org/pdf/H34272.pdf

Fadeyibi A., A. Halilu and Z.D. Osunde (2011). Analyses of physicochemical properties of abattoir wastewater for irrigation in Minna, Nigeria. Continental Journal of Water, Air and Soil Pollution, 2(2): 12-15, 2011.

FAO (1990). Food and Agricultural Organization: Guidelines for irrigation water standards.

FAO (1994). Irrigation water quality and wastewater reuse. Food and Agriculture Organization (FAO), Irrigation and Drainage paper No. 29, Rev. 1 (http://www.fao.org/docrep/003/T0234E/T0234E08.htm).

Horswell J., T.W. Speir and A.P. Van Schaik (2003). Bioindicators to assess impact of heavy metals in the land applied sewage sludge. Soil Biol. Biochem, 35:1501-15055.

Papadopoulos, I. (1988). Quality appraisal, experimental work and prospects for reusing treated effluents. Proceedings of the regional seminar on strengthening the near East regional research and development network on treatment and reuse of sewage effluent for irrigation, Dec. 11-16, Cairo, Egypt, FAO, Pp: 59-74

Samaila K.I., N.D. Marcus and S.B. Momale (2011). Efficient management of resources: wastewater application in dry season farming in Kaduna urban area, Nigeria. Medwell Journals, Vol. 6, Issue 4, Pp 183-193.

Scott C.A., J.A. Zarazu'a and G.F. Levine (2004). Urban wastewater reuse for crop production in the water-short Guanajuato river basin, Mexico. No 41, p 34.

Vigneswaran S. and M. Sundaravadivel (2004). Recycle and reuse of domestic wastewater, In: Wastewater recycle , reuse and reclamation [Ed. Saravanamuthu (Vigi) Vigneswaran], UNESCO, Eolss publishers, Oxford, UK (http://www.eolss.net)

WASH (2009): News about water, sanitation and hygiene (WASH) in Africa (http://washafrica.wordpress.com/). Accessed on 12/10/2012

WHO, (2006). Guidelines for the safe use of wastewater, excreta and grey water, Vol. 2, Wastewater use in Agriculture, Geneva.

Table 3.1 Measured Water Quality Parameters

Wastewater source	Irrigation Water Quality Parameter												
	pH	EC	TDS	Ca	Mg	Na	CO_3	NO_3	K	SO_4	HCO_3	Cl	B
Ona River	5.5-6.5	0.01-1.52	450-920	0.86-3.43	0.12-2.94	6.06-20.4	2.1-7.2	7.2-14.2	0.90-1.92	9.0-16.4	5.8-11.2	1.08-3.1	
NBC Plant	6.6	1.13	5.8								5.19	6	1.10
Abattoir	7.6	0.561	282		7.7	22.9			4.1			40.2	
Kaduna River	7.5	0.185	95	10.2	34	8.2		0.30	0.80			125	0.12

Units: EC (ds/m); Ca, Mg, Na, CO_3, K, SO_4, HCO_3, Cl (me/l); TDS, NO_3, B, Al (mg/l)
Locations: Ona river (Ibadan), Nigerian Bottling Company, NBC (Ibadan), Abattoir (Minna), Kaduna river (Kaduna)
Source: Adetayo (2012), Arku *et al* (2012), Fadeyibi *et al* (2011) and Samaila *et al* (2011)

Table 3.2 FAO Irrigation Water Standard

Water Parameter	Usual Range in Irrigation Water
Electrical conductivity (dS/m)	0-3
Total dissolved solids (mg/l)	0-2000
pH	6.0-8.5
Calcium Ca^{2+} (me/l)	0-20
Magnesium Mg^{2+} (me/l)	0-5
Sodium Na^{+} (me/l)	0-40
Boron B (mg/l)	0-2
Carbonate CO_3^{2-} (me/l)	0-1
Bicarbonate HCO_3^{-} (me/l)	0-10
Chloride Cl_2^{-} (me/l)	0-30
Sulphate SO_4^{2-} (me/l)	0-20
Nitrate NO_3^{-} (mg/l)	0-10
Ammonium NH_4^{-} (mg/l)	0-5

Source: FAO (1990)

SECTION III

POST HARVEST ENGINEERING

SELECTEDMOISTURE DEPENDENT PHYSICAL PROPERTIES OF COMMON BEANS, COWPEA AND YARD-LONG BEANS

Ndukwu M.C[1], Adama J.C[2]

Department of Agricultural and Bio-resources Engineering, Michael Okpara University of Agriculture, Umudike, P.M.B. 7627, Umuahia, Abia State. ndukwumcb@yahoo.com

ABSTRACT

The selected physical properties such as major diameter, minor diameter, thickness, sphericity, roundness, porosity, surface area, solid density, and bulk density were determined for all the three species of legumes. All parameters determined showed some deviations. The angle of repose ranged from 13.1-16.1^0 at a moisture content range of13.3%db. Comparatively among the three varieties of the legumes it was only the axial dimensions that significant statistical different exist at 0.5% level. For all the measured parameters the common bean has the highest standard deviation except for major and intermediate diameter. Also for all the measured parameters sphericity has the least standard deviation for the three species.

1.0 Introduction

Igene et al (2005) Reported that Protein energy deficiency has become the most common source of malnutrition in the regions where people depend mainly on starch based diet. In developing countries like Nigeria legumeshas always been the major supplement for expensive animal based protein. It can be processed into flour and used for making bean cake (akara) and porridge. In Sub-Sahara Africa, legumesare used for human consumptions while the remain are used as fodder, although some farmers would feed their working (draught) animals as supplements during the working season. In Nigeria the major types of beans grown are the common beans (*Phaseollis vulgaris*), cowpea (*Vigna ungulate*) and yard longbeans (*vignasegulpedalis*). The common beans are herbaceous annual plant domesticated independently and is now grown around the world. Botanically, the common beans are classified as dicotyledonous, as a legume, beans provide the nitrogen fixing bacteria which supplies those essential nutrients to other crops. The common bean is highly variable specie with a long history. Bush varieties form a red bushes 20-60 cm tall, while running varieties form vines 2-3 cm long. All varieties form alternate, green, purple leaves divided into three oral smooth dyed leaflets, each 6-15 cm long and 3-11 cm wide.

Cowpea (*vignaungulata*) is one of the important food legume crops in the semi arid and tropic regions covering Asia,Africa, Southern Europe and central and southern America. It is a drought and one weather crop. Cowpeas are well adapted to a dryer region of the tropic.It also has a useful ability to fix nitrogen through its root noodles and grows well in poor soil with more than 85% sand, with less than 0.2% organic matter and low land of phosphorus.In addition, they are shade tolerant and therefore compatible as later crop

The yard long beans (*vignasegulpedalis*) is also known as the long padded cowpea,despite the name;the pods are actually only about half a yard long.It is grown primarily for its strikingly long 35-75 cm one mature pod and has uses very similar to that of a green bean.The pods which begins to form just after sowing,hang in pair.

The growth and development of the three plant species are the same. Also,growth and development are partly conditioned by the environment.

Onwualu et al (2006) stated that in order to maintain steady food supply and stabilize food prices agricultural products should be processed into a more stable product or stored properly in a safe environment. Onwualu et al (2006) also concluded that in order to achieve this stability the physical properties are required for carrying out the unite operations (cleaning, coating, size reduction, drying etc.) in processing of agricultural product, design of planting and harvesting equipments. Also Sirisomboon et al (2007) also stated that parameters on the physical properties of biomaterial are important for effective and efficient design and construction of machines for handling, transportation, processing and storage of the product. According to Koya et al (2004), the relative size of a particle in a mixture is important in determining the separation by sorting while the shape with its coefficient of friction will determine whether the product will slide or roll during motion. Several authors (Olaoye , 2000; Ojeh et al, 2001; Baryeh and Mangope, 2003; Koya et al 2004; Adejumoh et al 2005) has, described the shape of biomaterial by the measurement of the linear dimensions, and used them to establish some of the physical characteristics of the material. Koya et al (2004) has also reported that the design of machine for shelling of agricultural material is influenced by the three axial dimensions while the geometric mean has been adequate in calculating the Reynolds number, projected area and drag coefficient of food grains which are needed in the design of pneumatic, fluidization and separation components of the machine. The coefficient of friction or the angle of repose is essential in the design of the storage structures, hoppers, separators etc based on the difference in surface texture of seeds and impurities while density is useful in the calculation of aerodynamic drag and the estimation of terminal velocity (Opeke, 1997; Koya et al 2004). Also the density will determine whether the material will sink or float in a liquid media. Therefore the knowledge of these physical properties of this seed is very important and need to be established and standardized for use in engineering design. Determination of the physical properties of agricultural materials is often problematic because of their diversity in shape, size, moisture content, and maturity level. Recent scientific developments have improved the handling and processing of biomaterials through mechanical and thermal devices.This work is aimed at determining the physical properties of *phaselousvulgris*(common beans),*vignasequpedalis*(yard long bean*),vignaungulata(*cowpea) in a comparative form. This is necessary since we cannot think of designing a machine which can handle and process the three species without having a proper pre-knowledge of the physical properties each,hence the importance of this researchwork. The irregular shape and porous nature of the three bean sample present difficulty in solving problems associated with volume and density measurement,surface area,surface color and appearance is a variable physical characteristicfor selective separation before subsequent handling, which is sorting and grading during storage.

2.0 MATERIALS AND METHODS

2.1 Materials

A sample size of 150 seed each was used, and then stored in container at room temperature (25^0C) to allow uniformity of moisture sample distribution (Ndirika and oyeleke 2006). The size and principal axes of the seeds (minor, intermediate and major) were determined using a digital caliper of precision to 0.01mm, and model GreprufteSichrhelt (GS) and made by Chirist Germany. The weight of the seeds was also determined using a digital scale of maximum

measurement of 400g and approximate error of 0.01g, model scout Pro SPU 405, made in China. The moisture content was carried out using a drying oven of model uniscopeSM9023, made in SurgifriendMedigals England. Angle of repose was determined using a T-square (diamond brand, made in China) and a stainless steel ruler made in Germany. Other material used is aluminum foil.

2.2 Methods

The seed dimensions such as minor, intermediate and major diameters (*L1*, *L2* and *L3*) respectively were obtained with the use of digital veneer calliper described above. The geometric mean diameter (D_g), Arithmetic mean(A_m), square mean(S_m) and equivalent mean(D_e) diameters was calculated from the equations presented by (Adejumoh et al 2005) and given below

$$D_g = (l1 * l2 * l3)^{1/3} \quad (1)$$

$$A_m = \frac{l1+l2+l3}{3} \quad (2)$$

$$S_m = \left[\left(\frac{l1l2+l2l3+l1l3}{3}\right)\right]^{1/2} \quad (3)$$

$$D_e = \frac{D_g+A_m+S_m}{3} \quad (4)$$

Also the method described by Oje et al (2001) was also used to determine the sphericity, roundness factor and roundness ratio and the equation is given below

$$S = \sqrt[3]{bc/a^2} \quad (5)$$

$$R_f = \frac{A_p}{A_c} \quad (6)$$

$$R_r = \frac{r}{R} \quad (7)$$

Where a- is the longest intercept, b- is the longest intercept normal to a, c- is the longest intercept normal to a and b. S- sphericity, A_p - largest projected area of the object in the rest position, A_c - area of the smallest circumscribing circle , R_f – roundness factor, R -radius of maximum inscribed circle within the traced outline, r - radius of curvature of the sharpest corner

The bulk density was calculated with the method described by Ndirika and Oyeleke(2006), this was done by packing some seeds in a measuring cylinder. The seed was taped gently to allow the seed to settle into the spaces. The volume occupied by the seed in the cylinder is used to calculate the bulk density as follows

$$B_d = \frac{weightofpackedseed}{volumeoccupiedbytheseed} \quad (9)$$

$$porosity = \left(1 - \frac{bulkdensity}{soliddensity}\right) \quad (10)$$

Solid density determination was carried out by using specific gravity bottle. This was carried out by first weighing the empty density bottle, followed by filling the bottle with some sample of seeds and then weighed again. The bottle was then filled with water and the mixture of the seed was weighed, the bottle is then filled with water and weighed. Finally, the solid density of the material was determined using the following equation as described by Okeke and Anyakoha (1987).

$$\text{Solid density} = \frac{m_2 - m_1}{(m_4 - m_1) - (m_3 - m_2)} * densityofwater \quad (11)$$

M_1= weight of empty density bottle (g)

M_2= weight of empty density bottle with some seed samples (20 seeds)

M_3= weight of density bottle filled with water and seeds (g)

M_4= weight of density bottle with only water (g)

2.3 Angle of Repose

The seeds were placed on the plywood which is placed on the T-square; the plywood was allowed to lie slanting on the T-square which was held at an angle of 90^0. Then the plywood was tilted until the seed began to slide (flow) freely, the angle the plywood makes with the T-square at the time of free flow was taken as the angle of repose of the seed (Ndirika and Oyeleke, 2006)

This procedure was repeated five times for seeds at different moisture contents to ascertain the mean angle of repose of the seed.

2.3 Statistical Analysis

Microsoft excel 2007 package for window vista was used to run the analysis. A student"t" test based on the equations presented by Dass (2008) below was used to test the significance level for the three species of the legumes;

$$t = \frac{X_1 - \mathrm{M}}{\frac{\mathrm{S}}{\sqrt{\mathrm{n}}}} \quad (12)$$

Where x_1. is the mean of each sample, M – is the mean of the population, s-is the standard deviation and n is the number of sample. Significance is accepted at $p < 0.005$

3.0 RESULTS AND DISCUSSIONS

3.1 Axial Dimensions

The physical properties of the three species of bean are presented in table 1-3. The axial dimensions are also presented in table 1-3. These axial dimensions were used to calculate the geometric, arithmetic and square mean diameters respectively. From the table 1, 2 and 3, the range of theses mean were 6.53 to 6.8mm,1.8 to 2.49mm and 2.23 to 2.55mm (for arithmetic ,

geometric, square mean and equivalent diameters) for the three species of common cowpea and yard long beans respectively diameters respectively with mean values of 0.12-0.15,0.07-0.11 and 0.49-0.79mm respectively. Despite the wide difference between the three dimensions of the bean (minor, intermediate and major diameters), it was found that the three mean (arithmetic, geometric and square mean diameters) diameters of each variety are very close. However when this values is looked for each variety it can be found that there is wide difference between the common beans and others. The geometric mean diameter of the common bean showed a 72.4% difference from cowpea and a 65.85% difference from yard long beans. This implies for a single machine to be used in the size reduction for the three species of beans, it must take this into consideration. Generally the physical properties showed deviations from the mean value which is common with agricultural materials. The average value reported in this study for the principal dimensions are higher than the other seeds like soybean, and millet (Ndirika and Oyeleke, 2006, Olaoye 2000).

3.2 Roundness Factor and Sphericity

The mean values of roundness factor and sphericity are (0.54 and 0.24) for common bean, (0.71 and 0.40) for cowpea and (0.70 and 0.50) for yard long beans. For common bean this values are low which implies that the seed cannot roll while for cowpea and yard long bean they are relatively high and can be seen from there shapes. Since the sphericity is a function of the geometric mean and major diameters it will also increase with increase in moisture content like the major diameters.

3.3 Bulk, Soliddensity and porosity

Solid and bulk density (0.49-0.53g/cm^{3}and 0.250-0.275g/cm^3) of the seeds arevery lower to that of water which explains why the seed can float in water at room temperature and this property is useful in designing the cleaning and washing machine as well as the soaking process for bean cake production. The value of density obtained is lower than some biomaterials like durra specie of palm nut (1.16g/cm^3) and Kano white variety of Bambara groundnut (1.45g/cm^3) (Adejumoh et al 2005, Koya 2004). However they are closer to that of some verity of millet (Ndirika and Oyeleke 2006). The porosity is very high and very close ranging from 49-53.5% for the three species of beans. This is very high which means it is very porous and explains why it absolves water and swell.

3.4 Coefficient of Static Friction and Angle of Repose

The angle of repose on plywood averaged 13.3-16.1^0±1.53^0-0.73^{0}while the coefficient of static friction ranged to 0.23-0.29 which implies that, the seed can slide very easily with a small angle of tilt. The low value might be due to the smoothness of the plywood surface coupled with the smoothness of the shell. This value is closer to that gotten by (Adejumoh et al 2005) on fibre glass for the palm nuts but lower than those gotten by (Laskowsky and Skonecki1,997)on three varieties of crushed legumes of horse, lupine and vetch bean (36.2-43.2^0).This is an important parameter in hopper design.

3.5 Comparison of the Physical Parameters:

From table 4, it can be seen that there is no significant difference between the roundness factor, bulk and solid density, porosity, angle of repose and coefficient of friction while the parameters

which are a function of axial dimension showed significant difference at 0.5% level for the three species. However, when this difference is closely looked at in table 4 it can be concluded that the common bean contributed more to this. The major, intermediate and minor diameters of common bean vary widely from that of other two species. This is typical of crops of the same species but different variety and agrees with a similar work done on two variety of millet by Ndirika and Oyeleke(2006)

4.0 CONCLUSION

The physical properties of three species of beans have been established. From the result of this study, the following conclusion can be made;

1. The physical properties showed deviations with the mean value just like all biological materials.
2. There is wide variation between the axial dimension of the common beans and the two other species considered
3. Due to low value of the sphericity, and roundness factor of common bean it can be concluded that, the seed cannot roll.
4. The small value of the angle of repose and coefficient of static friction implies that with little tilt angle the seeds can slide freely which is very useful in hopper design.
5. The porosity is very high and close to each other which is useful in the boiling or soaking processes of the seed.
6. In comparing physical properties of the three varieties of the legumes it was only the axial dimensions that significant statistical different exist at 0.5% level.

REFERENCES

Adejumoh O.I, Alfa A.A,Muhmmed .A .2005. physical properties of Kano white bambara ground nut Proceedings of Nigerian Institution of Agricultural Engineering. Vol 27 pp 203-210.

Baryeh A.E, Mangope B.K, 2003. Some physical properties of QP-38 variety of pigeon pea *Journal of food Engineering 56(1)59-65.*

Enebong, H. N. and Carbonale, E. 1992.Nigeria Soup Condiments. Traditional Processing and Potentials as Dietary Fiber Sources. Food Chain Chem. Pg 29 – 34.

Dass .H.K. (2008) ; Engineering mathematics. S . Chand and Company New Delhi

Igene.J.O, Salami.L.I, Nkama. I, Negbenebor ,CA., Obinomen S.A, 2005. Physiochemical properties of cassava starch- based fish and beef crackers. *Journal of raw material research 2(1) pp 26-33.*

Jain R.K and Bal S. 1997.physical properties of pearl millet. *Journal of agricultural engineering research,66:85-91*

Koya .A, Idowu .A, Faborede .M.O 2004. Some properties of palm kernel and shell relevantin nut cracking and product separation. *Journal of agricultural engineering and technology volume 12*

Krause, J.P, Mothes, R and Schwenke, K.D .1996. Some physiochemical and interfacial properties of native and acctylated legume from fabaceae bean (Viciafaba L.). J*ournal of Agricultural Food Chemical* 44: 429-437.

Laskowsky.J and Skonecki.S 1997 Influence of moisture on the physical properties and parameters of compression process of lgumes seed *intagrophysics* (11) 245-256

Nderika, V.I.O.andOyeleke O.O. 2006 Determination of selected physical properties andthire relationship with moisture content for millet (pennisetumglaycum) .*Applied Engineering in Agriculture*, 22(2), 291-297

Oje, k, Alonge, A.F, Adigun Y.J 2001. Some engineering properties of shear nut relevant to mechanical processing. *Ife journal of technology 10(2):17-20*.

Olaoye , J.O. 2000. Some physical properties of castor nut relevant to the design of processing equipment. *Journal of Agricultural Engineering Research,77(1) 113-118*

Onwualu A.P, Akubuo C.O, Ahaneku I.E. 2006; Fundamental of Engineering for Agriculture

Immaculate publication Ltd Enugu

Opeke, L.K.1997 Tropical tree crops. John Willy and sonschischester

Okeke, P. N. and Anyakoha S. M. 1987. Senior Secondary Physics, Revised Edition. Dickson press. Nigeria

Sirisombom, P. Kitchaiya, T. Phoslpho, W.Mahuttanyavanitch (2007). Physical and mechanical properties of Jastrophacurcas.L .fruits, nuts and kernels.*Biosystem engineering 97; 201-207*

Table 1: variations in the physical properties of *phaseolusvulgaris (common beans)*

Parameters	No of samples	Mean value	Standard deviation
Roundness factor	150	0.54	0.43
Major diameter(mm)	150	8.58	0.67
Intermediate Diameter(mm)	150	6.39	0.58
Minor Diameter (mm)	150	5.07	0.94
Geometric mean	150	6.53	0.12
Arithmetic mean	150	6.68	0.15
Square Mean	150	6.60	0.13
Equivalent mean	150	6.60	0.12
Sphericity	150	0.24	0.02
Bulk Density(g/cm^3)	150	0.275	
Solid Density (g/cm^3)	150	0.53	-
Porosity (%)	150	51.9	
Moisture Content(%)db	150	13.3	-
Angle of repose on Plywood (^{0})	150	13.73	1.53
Coefficient of Static Friction	150	0.23	

Table 2: variations in the physical properties of *vigna-ungulata(cowpea)*

Table Parameters	No of samples	Mean value	Standard deviation
Roundness factor	150	0.71	0.23
Major diameter(mm)	150	4.52	1.33
Intermediate diameter(mm)	150	2.4	1.01
minor (mm)	150	0.54	0.034
Geometric Mean	150	1.8	0.09
Arithmetic Mean	150	2.49	0.11
Square Mean	150	2.20	0.11
Equivalent Mean	150	2.16	0.07
Sphericity	150	0.40	0.06
Bulk density(g/cm^3)	150	0.273	
solid density (g/cm^3)	150	0.51	-
Porosity (%)	150	53.5	
Moisture content(%)db	150	13.3	-
Angle of repose on plywood (^{0})	150	16.09	0.73
Coefficient of static friction	150	0.29	

Table 3: variations in the physical properties of *vignasegulpedalis (yardlong beans)*

Table Parameters	No of samples	Mean value	Standard deviation
Roundness	150	0.70	0.25
Major diameter(mm)	150	4.50	0.91
intermediate diameter(mm)	150	1.65	0.84
minor (mm)	150	1.50	0.87
Geometric Mean	150	2.23	0.49
Arithmetic Mean	150	2.55	0.79
Square Mean	150	2.35	0.75
Equivalent Mean	150	2.38	0.78
Sphericity	150	0.50	0.21
Bulk density(g/cm^3)	150	0.25	
solid density (g/cm^3)	150	0.49	-
Porosity (%)	150	49	
Moisture content(%)db	150	13.3	-
Angle of repose on plywood (^{0})	150	16.1	0.72
Coefficient of static friction	150	0.29	

Table4: Comparison of selected physical properties of three legume varieties (common, cowpea and yard long beans) atumudike in 2008

Parameters (mean value)	Common bean	cowpea	Yard long bean	Cal "t"	Table "t"	Sig (p<0.005)
Roundness factor	0.54	0.71	0.70	11.8	9.925	ns
Major diameter(mm)	8.58	4.52	4.50	4.32	9.925	*
Intermediate diameter(mm)	6.39	2.4	1.65	2.36	9.925	**
Minor diameter (mm)	5.07	0.54	1.50	1.64	9.925	**
Geometric Mean diameter(mm)	6.53	1.8	2.23	`2.32	9.925	**
Arithmetic Mean diameter(mm)	6.68	2.49	2.55	2.82	9.925	**
Square Mean diameter(mm)	6.60	2.20	2.35	2.58	9.925	**
Equivalent Mean diameter(mm)	6.60	2.16	2.38	2.57	9.925	**
Sphericity	0.24	0.40	0.50	5.06	9.925	*
Bulk density(g/cm^3)	0.275	0.273	0.25	33.14	9.925	ns
solid density (g/cm^3)	0.53	0.51	0.49	44.17	9.925	ns
Porosity (%)	51.9	53.5	49	21.92	9.925	ns
Moisture content(%)db	13.3	13.3	13.3	-		
Angle of repose on plywood (^{0})	13.73	16.09	16.1	19.43	9.925	ns
Coefficient of static friction	0.23	0.29	0.29	13.51	9.925	ns

ns- not significant, * -significant, **- highly significant

DEVELOPMENT OF A DIFFUSE LIGHT STORE FOR "SEED" POTATO STORAGE

F.A. Babarinsa[1] and Williams, J.O.[2]

Nigerian Stored Products Research Institute, P.M.B. 1489, Ilorin. Nigeria. *Phone*: +2348033797653 *E-mail*: fababarinsa@yahoo.com

ABSTRACT

A low-cost 2-tonne capacity diffuse light store (DLS) was designed and constructedfor storage of "seed" potatoes. The DLS was built of clay bricks and provided with ventilation vents at the bottom and the top of the storage room. Natural diffuse light was admitted through wall openings covered with polyethylene sheets. The store was tested for storage of 'seed' potatoes and compared with the traditional storeroom (TSR) conventionally used by potato farmers of the highland (mountainous)area of Plateau State of Nigeria. During the 16 weeks' storage, the average temperature in the DLS dropped 5^{o}-10^{o}C below the ambient and relative humidity was reduced by 25%. "Seed" potatoes of the Nicholas variety successfully stored for 16 weeks in DLS. The DLS performed better than traditional storeroom (TSR) by reducing losses due to weight loss and rottingby 54.2%and 44.7% respectively, due presumably to the applied convective ventilation. The higher losses in seed in the TSR were considered attributable to high temperature and respiration in the store which was corrected,in DLS, through convective ventilation.

Keywords: Diffuse light store, Storage, 'Seed' potato, Rotting, Weight loss, Convective ventilation.

1. Introduction

Irish potato (*Solanum tuberosum* L.) has become an important crop in Nigeria and its production has been on the increase in the past two decades. The crop is particularly widely grown in the middle-belt zone especially in the mountainous area of the Plateau State where it adapts best to the cold climate. However, the non-availability of "seed' potatoes for planting poses the major constraints facing farmers in their drive towards intensive production. These problems are closely associated with lack of storage facilities for the seed potatoes in-between growing seasons (Okonkwo et al., 1986). Traditionally the seed potatoes (which are small tubers of previous crop) are stored in baskets kept in household rooms or in any available place in farm buildings. These stores are kept nearly totally dark and are inadequately ventilated. Under this condition, the small tubers deteriorate fast and lose viability shortly after harvest. The major problems are related to weight loss due to desiccation, rotting and excessive sprouting. Okonkwo et al. (1986) reported that farmers lose as high as 40% of their stored seeds within three months of storage as a result of poor storage.

In this respect, notable success of seed potato storage has been made in developing countries on the development of techniques and designs for using natural diffuse light in the storage of seed tubers (Anonymous, 1980, Potts et al., 1983 and Nwokocha and Ifenkwe, 1991).Potts et al. (1983)noted that the development of diffuse light seed storage technology by the International Potato Centre (CIP) has made it practicable to store seed potatoes even at tropical temperature,

largely because light suppresses excessive sprout growth.Diffuse light storage technology is effective in reducing storage losses and results in better quality seed value due to weight losses and growth of short robust sprouts instead of long, thin and weak ones. The admitted diffuse light suppresses premature and excessive sprouting (Potts et al., 1983 and Wiersema and Booth, 1985).Temperature ceases to be very critical because tubers can be successfully stored and maintained in acceptable physiological conditions(Anonymous, 1980). Additional advantages of diffused light over dark storage are increase in sprout number and increased resistance to several pests and diseases due to tuber greening and a reduction in apical dominance, which limits the number of stems that can develop from a planted seed. Natural diffused light has been recommended by Booth and Shaw (1981) as an alternative to low temperatures to control excessive sprout growth for storage of seed potatoes), particularly in simple low cost structures which are appropriate to for small farmers. These workers showed a range of sizes and construction in use of diffused light seed stores. Various potato varieties have also been stored under diffuse light store in Bangladesh (Hossain, et al., 1995).

This paper assesses the effect of using a diffuse light store developed with consideration of simplicity of construction and employment of locally available materials and skill. In this trial, a comparison was made between the DLS store and the traditional storeroom.

2. Materials and Methods

2.1 Store design and construction

A rectangular diffuse light structure (DLS) was constructed (at Kuru in the Plateau state of Nigeria) with local materials, mainly clay bricks, with a storage room 4.5x4.0x2.0m. One end side of the store has an access door made of sawn wood (Figure 1). Figure 2 shows the rear side. To admit diffused light (indirect sunlight) into the storage room, each side wall carries two sets of wall perforations 18cm x 18cm covered with transparent polyethylene sheets. The two side walls facing wind direction carry, in addition, two rows of rectangular vents 40cm x 22cm to induce convective ventilation in the store space. One row of four inlet vents is located at the floor level while the other row of four outlet vents are at the eave (wall top) level (Figure 3). The inlet vents are inwardly covered with control flaps consisting of polypropylene sheets cut to size and hung to the top edge; they open intermittently according to the prevailing wind direction. Flapped vents arrangement is flexible and also enables the airflow to be reduced for a high wind condition to prevent excessive potato shrinkage. To maximize wind influencing the ventilation, the long sides of the store are oriented to face prevailing wind direction. Whenever the flaps on one side open those on opposite walls close. Because only the set of inlet vents on one side opens at a time, intake air current is prevented from being short circuited by a cross flow across the floor level.

With the above vent arrangement, convective ventilation is induced in the storage space by upward air displacement as ventilating wind is admitted through the floor level vents. At nights, cold night air enters below the storage space and warm air exits above. This is complemented by the convection current resulting from the bottom-to-top temperature gradient naturally caused by evolution of heat from respiring tubers. The convective airflow is activated by temperature difference between the potatoes and the outside air. This system lowers the storage temperature by flushing the store with in-flowing night cool air to intermittently replace daytime hot air. The exit of warm moisture-laden air generated by the tubers also reduces the chances of rotting in the tubers. All wall openings, vents and perforations, are protected with wire netting to exclude

rodents, reptiles and birds. The store roof is constructed of thatch materials, consisting of "zana" grass and wooden trusses. The floor is rammed with a top layer formed of sand-cement mixture 5cm thick.

Slatted wooden shelves were provided in the store for loading potatoes for storage. These comprise a set of three racks, 80cm wide, fixed to the side of each wall with the racks vertically spaced 60cm. The ventilated shelves are rugged and seed tubers can be stored on them to a maximum depth of 2 to 3 tubers to permit light access to all tubers. Each rack is compartmentalized such that stored potatoes are carried as identifiable lots. Constructing slated shelves aligned to the walls allows optimal ventilation as well as providing a central space or alleyway for handling activities. *Okonkwo et al.* (2003) recommend storage in crates, racks and on floor of well-ventilated stores for short-term (4 months) storage, since these methods provide good ventilation of stored seed and tuber rots are low.

2.2 Seed potato storage

Seed tubers of Irish potato, of Nicholas variety were used in experimental storage trial for assessing the DLS performance.T he seed tubers, between 40mm and 50mm long, were freshly harvested and divided into three lots. Each lot consisted of 450kg of tubers, subdivided into three units and laid on the three racks. A comparative storage trial was conducted under the simulated field loading condition of the farmer using a traditional storeroom. The potato units were randomly placed in different locations within the stores. Daily temperature and relative humidity in the stores and ambient were recorded using thermo hydrographs and glass thermometers. Fortnightly records were taken of weight loss, incidence of rot and incidence of sprout for a storage period of 16 weeks.

3. RESULTS AND DISCUSSION

3.1 Storage temperature and relative humidity

During the experiment, ambient temperature ranged between 13.6^{o}to 27.5^{o}C(characteristic of Jos plateau) with a mean of 23.6^{o} C. The daily average temperature in the diffuse light store (DLS) was within the range of 15.8^{o} to 21.9^{o}C and a mean 17.9^{o}Cwhile the traditional storeroom(TSR) had a range of 14.6 ^{o} to 28.9^{o}C with a mean 22.1^{o}C. Thus, both the temperature and temperature fluctuation in the DLS were persistently lower than those obtained in the traditional storeroom.

3.2 Weight loss

Weight loss was observed in tubers stored in both stores. After two weeks, most of the tubers in the DLS had dry skin, showing adequate curing, when the weight loss was 0.8% (Table 1).After 8 weeks, recorded weight loss was 5.5% in DLS and rose to 18.5% in TSR. After 16 weeks, weight loss increased further to 8.9% in DLS and 35.8% in TSR. Average mean loss in weight was 17.8% and 38.9% in DLS and TSR respectively. There was persistently higher weight loss in the TSR than in the DLS and the higher moisture losses in the TSR were revealed by the more shriveled tubers. The higher losses in seed weight in the TSR were presumably due to poor ventilation and thus high temperature and respiration in the store. Weight loss occurred most prominently in top layer tubers, indicating an influence of surface ventilation.

3.3 Rotting

Rotting also increased with storage time. Before four weeks of storage, there was no remarkable difference in the percentage rotten potatoes in the two storage methods**.** After 8 weeks, however, rotting became greater in the traditional storeroom (TSR), reaching 10.4% (Table 1).This was reduced to 4.8% in the diffuse light store (DLS). After 16 weeks, rotting was greater in the TSR, reaching 19.6 % as compared to 9.4% in DLS. The overall mean losses in seed number, mainly by rotting, were21.9 % in TSR but were reduced to 12.1% in DLS. Most of the deterioration in the TSR was primarily due to rotting occurring at the lower layers of tubers where localized heating might have occurred due to lack of adequate ventilation. Lack of adequate ventilation is a known factor favouring the development of rotting in potatoes (Potts et al., 1983).

3.4 Sprouting

Before four weeks of storage, there was no noticeable sprout growth in all the healthy seed potatoes in the two stores. After 12 weeks in DLS the percentages of sprouted tubers were 15.8% in TRS and 8.6% in DLS. The average number of sprouts per tuber was reduced from 1.86in the TRS to 1.3 in DLS. The average length of apical sprouts was also reduced from 16mm to 10mm. Furthermore the DLS sprouts were shorter, green and sturdy (robust) as opposed to the long, thinner, white and easily damaged sprouts on the tubers from traditional store. In seed potatoes storage, diffuse light is a factor which causes a remarkable toughening of the sturdy sprout and markedly reduced excessive sprout growth in the seed tuber**(**Potts et al., 1983).Storage of seed potatoes in DLS is a way of reducing apical dominance and increasing number of sturdy sprout (Booth and Shaw, 1981. and Meijers 1978). Meijers (1981) particularly noted that lowering of temperature, as well as lowering of range of temperature, within seed potato stores is a desirable feature that helps to prolong dormancy period of tubers. The development of high quality sprouts in the DLS, which reduced losses were due in part to the effect of diffuse light. Commencement of sprout growth increases water loss because permeability to water vapour is higher on the surface of the sprouts than from the periderm of the tuber (Anonymous, 1960).Excessive sprouting therefore contributes to both weight loss and desiccation. It has been established that ensuing vigour of plants from shorter and sturdy seed tubers is better in the field (Anonymous, 1960).

3.5 Store performance

Regardless of storage method, spoilage was more rapid during the last two weeks. Deterioration of storeroom tubers was presumably due mainly to heat built up resulting from respiration within the pile ((Burton, 1969).The reduced spoilage in the DLS can thus be attributed to improved conditioning due to better ventilation and prevention of temperature rise in the DLS. The use of convective ventilation has long been identified as the cheapest form of cool storage and, consequently, reduction of loss in seed potatoes (Burton, 1969).With the system of ventilation applied, the DLS has demonstrated suitability for the potato production areas of Plateau State in Nigeria because ambient temperatures are usually low enough, particularly at night. The temperature in the ventilated DLS can thus be low enough to inhibit excessive sprouting for about 3 months before the planting season. Ventilation has also an emergency function in cooling or drying out patches of rot until they can be removed (Annonimous, 1972; Burton, W. G., 1978).Nwokocha and Ifenkwe (1991) have noted that the 3 to 4 months of storage is considered sufficient for the farmer to escape the potato glut that is experienced each year.

3.6 Economic viability

The material and labour for the traditional store cost about ₦24,000 (US$160). The extra cost of creating vents and openings on the DLS walls was about ₦2,000 (US$13.3) while extra maintenance cost was minimal. The 200kg of seed potatoes saved in each loading amount to a gain of ₦8000 (US$53.3) a growing season; so the reduced losses more than offset the extra cost of the DLS in four growing seasons. Economic viability of the storage method is thus apparent.

4. CONCLUSION

This work has expanded the technological base to check storage losses in fresh seed potatoes, which limit potato production in Nigeria. In the developed diffuse light store, favourable conditions for extended storage life of seed potatoes employs a passive system whereby the tubers are exposed to natural diffused light and ventilated on shelves by exposure to ambient condition and to convective ventilation under the cool highland condition. It effectively checked the losses caused by sprouting, rotting and weight loss. The system is economically viable for small and medium scale producers under tropical conditions.

REFERENCES

Anonymous (1960). Bulk Storage of Potatoes in Building. *Bulletin No. 173, Ministry of Agriculture, Fisheries and Food.*

Anonymous (1972) Potatoes. *Bulletin 94*, Her Majesty Stationery Office, London.

Anonymous (1980).Potato storage for developing countries. *Tropical Products Institute, Newsletter* 17, April 1980.

Booth, R. H & Shaw, R. L. (1981) *Principles of Potato Storage*. International Potato Centre (CIP), Lima, Peru.

Burton, W. G. (1969) Notes on the Physiology and Biochemistry of Potato in relation to Storage Requirements. Paper 1,*Papers Presented at the Symposium on Potato Storage*, Organized by the Potato Marketing Board, and held at the Charing Cross Hotel, London, on the 6th November, 1969. pp7-9.

Burton, W. G. (1978) The physics and physiology of storage. In: Harris P. M. *The Potato Crop* (ed.),Chapman and Hall. London. pp545 – 606.

McGee, E., Booth, R. H, Jarvis,M. C. &Duncan,H. J. (1987). The inhibition of potato sprout growth by light. 1: Effects of light on dormancy and subsequent sprout growth. *Ann. Appl. Biol*. 110: 399 – 404.

Hossain, M. J., Bhuiyan, M. K. R., Zakaria, M. &Rashid, M. M. (1995). Evaluation of some British potato varieties for keeping quality under natural storage conditions in Bangladesh. *Tropical science* 35:113-120.

Ifenkwe, O. P. (1980).A review of the status of potato production in Plateau State of Nigeria . *Res. Bull. 1. N. R. C. R. I., Umudike. Mc*

Meijers (1978).*Potato Storage in Warm Countries*. Dutch Information Centre, The Hague, Holland.

Nwokocha, H. N.& Ifenkwe, P. O. (1991) Construction and evaluation of seed and ware potato stores. In: Olukosi, J. O. and Ogungbile, A. O. (991) *Appropriate Agricultural Technologies for Resource-Poor Farmers.* pp 83-99.

Okonkwo, J. C., Amadi, C.O., Nwokocha, H.N., Williams, J.. O. &Okoye, W. I. (2003) Assessment of six storage methods for seed potato storage in Nigeria. *Nigerian Agricultural Journal.* 34 : 91-96

Okonkwo, J. C., Nwokhocha, H. N. & Ifekwe,O. P. (1986). Survey report on potato production and storage in some storage in some Local Government area of Plateau State. Ann. Report, Nat. Root Crops Res. Inst. Umudike, pp. 33 – 35.

Potts, M. J. (1983). Diffuse potato storage as an example of technology transfer : A case study. *American Potato Journal* 60:217 – 226

Potts, M. J.,Albert, W. V. D., Rutab, F. R. Sano, E. .O. Mariano, P. P. &Booth, R. H. (1983). An agro-economic assessment of seed-potato storage technologies in the philipines. *American Potato Journal*. 60:199-211.

Wiersema, S. G. &Booth, R. H (1985). Influence of growing and storage conditions on the subsequence performance of seed potatoes under short-day conditions. *Potato Research* 28: 15-17.

ACKNOWLEDGEMENTS

The authors acknowledge the assistance of the technical staff of the National Root Crops Research Institute, Vom-Jos, Nigeria, for the technical assistance in data collection on the structure. We also express our appreciation to the National Agricultural Research Project (NARP) for providing the grant for the work.

Table 1: Weight loss, rotting and sprouting of "seed" potatoes stored in diffused light store (DLS) and traditional storeroom.

Storage time (weeks)	Weight loss (%)		Rotting (%)		Sprouting (%)	
	DLS	TSR	DLS	TSR	DLS	TSR
2	0.8	3.4	0.5	1.8	0.3	0.4
4	2.4	7.2	1.9	4.3	2.5	3.5
6	4.6	13.8	3.2	8.4	3.8	7.3
8	5.5	18.4	4.8	10.4	4.4	11.5
10	6.9	22.3	6.5	13.2	5.2	14.2
12	7.8	26,9	7.7	15.6	6.5	18.0
14	8.6	31.3	8.1	17.8	8.8	22.3
16	8.9	35.8	9.4	19.6	10.4	24 7

DLS = Diffuse light store, TSR = Traditional storeroom

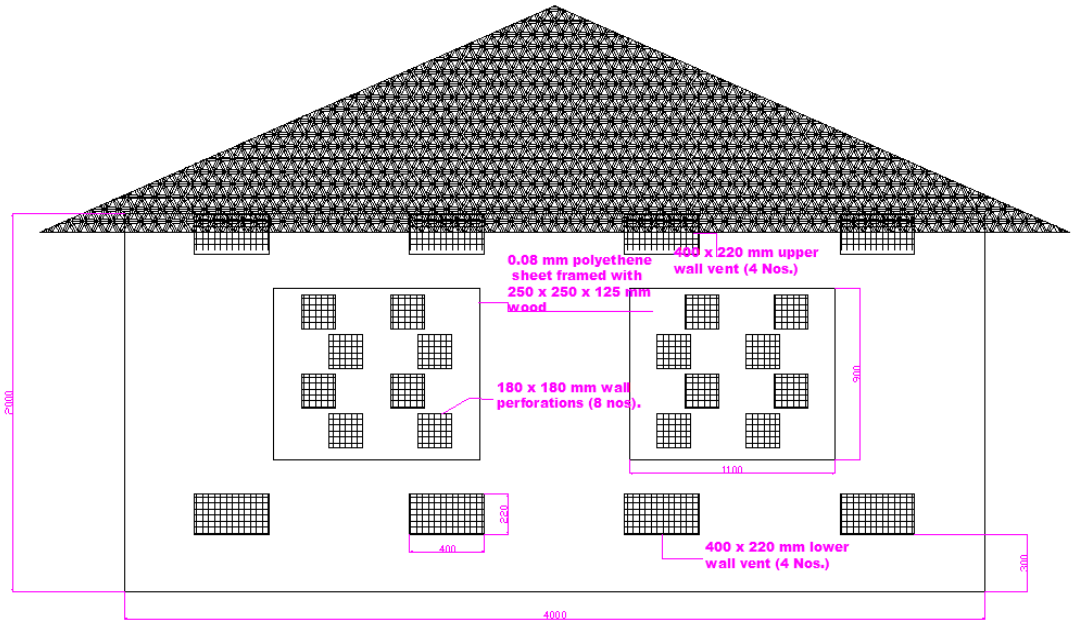


Figure 1: Front View of the Diffuse Light Store

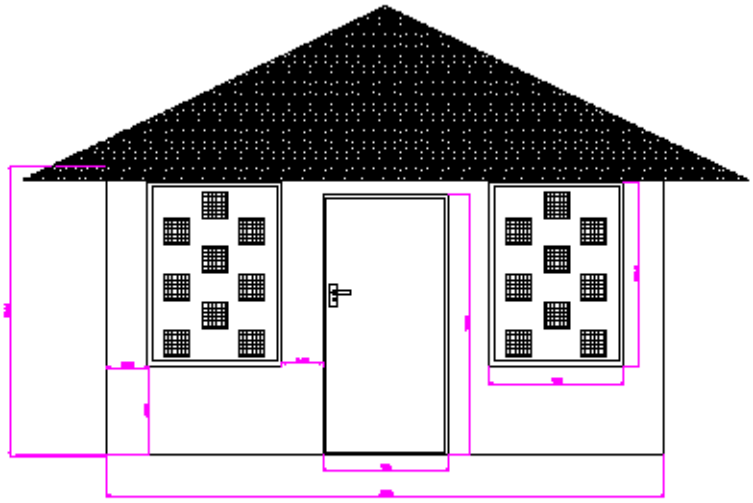


Figure 2: Rear View of the Diffuse Light Store

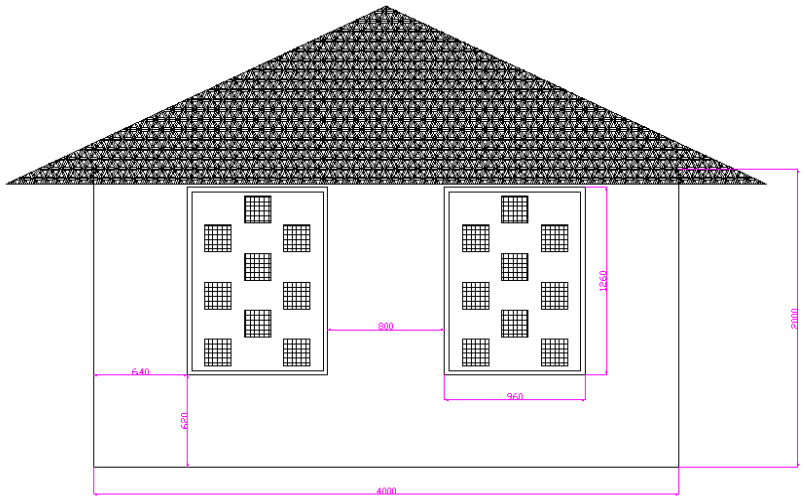


Figure 3: Ventilated Side of the Diffuse Light Store

ELECTRICAL RESISTIVITY AND CONDUCTIVITY OF IRVINGIAGABONENSIS AND MUCUNAFLAGELLIPES AT DIFFERENT TEMPERATURES AND THEIR RELATIONSHIPS WITH SOME PHYSICAL PROPERTIES

Ndukwu M.C andNwauisi K.O

Department of Agricultural and Bio-resources Engineering, Michael Okpara University of Agriculture, Umudike,P.M.B. 7267,Umuahia,Abia state, Nigeria (ndukwumcb@yahoo.com, ndukwumcu@gmail.com)

ABSTRACT

The Investigation of electrical resistivity and conductivity of irvingiagabonensis (wild mango) and mucunaflagellipeswas done at a temperature range of 20^0-50^0F (-6.6-10^0C). The resistivity and conductivity was not steady as it showed both minimum and maximum value at different temperatures. On the average the electrical resistivity decreased with increase in temperature while conductivity increased with increase in temperature. Unlike non bio- products the increase or decrease in electrical resistivity and conductivity was inconsistent with the thickness and diameter of the bio- products, however temperature and moisture contents has a more significant effect. The average minimum value of electrical resistivity was within the range of 9.89 x10^5 - 1.80 x10^6Ωm at a temperature of 50^0F -20^0F, for mucunaflagellipes. While for irvingiagabonensis it was 4.67 x10^5 -5.40 x10^5 Ωmat temperature of 50^0F -20^0F. The average maximum values, ranged from-9.51 x10^5- 1.16 x10^6 Ωm for mucunaflagellipes, while for irvingiagabonensis it ranged from 5.63 x10^5 -5.09 x10^5Ωm at the same temperature range. Also the minimum value of electrical conductivity ranged From 1.14 x10^{-6} - 1.46 x10^{-6} s/m at 20^0F- 50^0F for mucunaflagellipes, while for irvingiagabonensis,it was 2.63 x10^{-6} - 3.05 x10^{-6} s/m at 20^0F- 50^0F.

Key words: resistivity, conductivity, temperature, moisture contents

1. Introduction

Agricultural products are of a great importance in human nutrition as they supply vital nutrients to the diet, provide variety to the food and make them appetizing and more attractive (Abdul 1989). Many methods have been adopted in the preservation and processing of agricultural materials. Some of these methods range from common sun-drying to refrigeration etc. However, in the recent past, electrical treatment has become acceptable in processing of bio - materials (Ranalli et al., 2002). This has led to the design of some processing equipment which makes use of the electrical resistivity and conductivity of the product. Some of these appliances uses the principle of ohmic or resistance heating and inductive heating. Cetin and Topcu,(2009); reports that electric current flowing through biomaterials decreases the microbial count by preventing cold shortening and improves quality of the product. The application of electrical treatment in the processing of bio - materials requires the knowledge of electrical properties and their effects on processing (Icier and Baysal, 2004) thus, electrical properties of biomaterial has become an important area of research in order to determine adequate process parameters in designing these equipment for the processing of the products particularly automated mass production system commonly used in Industries (Saif et al., 2004a, Saif et al., 2004b, Mahapatra et al., 2007). Also some of the electric properties of seeds are well correlated with moisture content (Nelson, 1991) and are highly dependent on temperature. Therefore, electrical moisture meters have been developed for rapidly sensing seed moisture content. Modern agriculture requires moisture

sensing on moving bio materials for continuous monitoring of moisture content on harvesting, conveying and processing equipment (Nelson, 2006). Some of these parameters have been determined for some selected agricultural products like apples; strawberries etc. However literature on MucunaFlagellipesand Irvingia is scarce. MucunaFlagellipes is the third largest among flowering plants, consisting of approximately 650 genera and 20,000 species (Doyle, 1994) and it is the second most important plant source of human and animal nutrition. The seeds often have a hard coat with hourglass cells and sometimes bear a u-shaped line called a pleurogram (www.zipcodezoo.com/plants).

Many varieties of the Mucuna are in great demand in food and pharmaceutical industries. Nutritional importance of Mucuna seeds as a rich source of protein supplement in food has been well documented (Siddhuraju, 1995;Bressani 2002).

Irvingia figure 2 with a common name wild mango, African mango or bush mango is a genus of Africa. They bear edible mango like fruits and are especially valued for their fat and protein rich nut (Ehiem and Simonyan 2010). The aromatic nuts are typically dried in the sun for preservation and are sold whole or in powder form. IrvingiaGabonesis lowers blood pressure and blood hip cholesterol levels. As a natural fiber, it slows the gastric erupting process and helps you maintain fullness for longer periods of time. When used correctly, it demonstrates impressive results in the areas of weight loss, leptin control and health benefits (David and Ladipo 1996).

In Africa this two important seeds are widely used as soup thickener or roasted and eaten as food for the elderly.Buyers of these seeds rely on locals which adopts the crude method of processing which is often not reliable, with low output, poor packaging with poor visual appearance and sometimes lead to food poisoning. An understanding of electrical resistivity and conductivity behavior of the seeds would enable us to optimize the electrical parameters that could be used in designing appropriate techniques to apply electrical stimulation to inactivate harmful pathogens that can contaminate them and adopt automated processing line in there processing and packaging. Though some of the electrical properties of some agricultural products have been established but literatures on Irvingia and mucunabased on these properties is very scarce or not available, and this has led to the inability of agro- processors to adopt the modern techniques to process these products. Thus, denying users the optimum benefit derived from high technology processing ofthese agricultural products.

2. MATERIALS AND METHODS

Mucunaflagellipis, irvingiagabonensis were gotten from open market because there is no known plantation for the crops. They are local seeds and mostly grows in the wild. The seeds were then removed from the pods and thoroughly cleaned and sorted by hands to remove dirt and chaffs. Individual seeds was weighed on a digital weighing scale (scout pro SPU 401, made in China). The seeds were grouped based on their weight and the modal weight was chosen for the experiment. The seeds were tied in a poly bag and kept at room temperature to obtain a uniform moisture distribution throughout the seeds (Ndukwu and Ozoude 2009). Due to the glassy nature of the seed coats, which makes water absorption difficult, the seed coat were removed and the cotyledon split longitudinally into two through the helium. The axial dimensions of the seeds were measured using digital veneer caliper.The split cotyledon was thoroughly cleaned andplaced in a refrigerator at temperatures of20˚F(-6.6^{0}C), 30˚F(-1.1^{0}C), 40˚F(4.44^{0}C)and 50˚F(10^{0}C) for five hours. A direct current digital resistance probe with a clip equippedwith amultimeter DT92

series (3-1/2-4-1/2 digit LCD model, DT9203A/DT9204A) with a maximum reading of $19999X10^{6}\Omega$ was used for resistance measurements. To maintain a steady voltage, the probe was powered through a converter by sawafuji generator (SH 3200 EX, 50HZ, Phase 1ø, rated power 2.4 -2.6KVA) with maximum DC output of 12V. The positive probe was softly clipped on one end of the seed and the negative probe on the other end. Because resistance does not have polarity, the positioning of the probe was not considered since it does not affect its polarity. The probe was left for 60secods because of the fluctuating movement of the digital meter. The minimum and maximum range of resistance was read from the multimeter. This was done at constant moisture contents of 6.75%db for irvingiagabonensis (wild mango) and 18.7%db Mucunaflagellipis, for differenttemperature range of $20\text{-}30^{0}$F. The split cotyledons were further conditioned by soaking in distilled water inside a calibrated beaker 250ml for 24-72hrs to absorb moisture and then each removed, cleaned and placed in a refrigerator at temperature of 30^{0}F(-1.1^{0}C) for 3hrs. The experiment was completed in triplicate and the average taken and recorded. Electrical resistivity was determined mathematically using the general formula. Also the cross-sectional area was determined mathematically using the general formula

$$\partial = \mathcal{R}\frac{A}{\lambda} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where $\mathcal{R}$ is the electrical resistance of a uniform seed (biomaterial) measured in ohmsΩ.

A is the cross sectional area measured in mm^2.

$\lambda$is the major diameter of the seed measured in mm

The cross-sectional area is given by

$$A = \frac{\pi d^2}{4} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

Where d is the diameter of the biomaterials measured in mm.

The electrical conductivity was taken as the inverse of the electrical resistivity.

3. RESULTS AND DISCUSSION

3.1 Effects of Temperature on Electrical resistivity of IrvingiaGabonensis and MucunaFlagellipes

The effect of temperature on electrical resistivity of irvingiagabonensis and mucunaflagellipes at 20°- 50°F is shown in figure 3-4.There were significant different between temperatures in terms of these biomaterialsat 5% confidence level. Temperature is an important factor which affects the flow of electricity. The resistivity decreased with increase in temperature as shown in figure3 and 4. This implies, there is much less resistance at a higher temperature than at a lower temperature which shows the behaviour of the material as either an insulator or a semi conductor (Mahapatra et. 2010).This is an important parametric consideration for agro-processors and food Engineers in the design of temperature dependent equipment for the processing of biomaterial. The electrical resistivity fluctuated between a minimum and maximum value and Grimnes and Martinsen, (2000) suggested that this might be as a result of cells or tissues of the bio-materials moving from one physiological state to another. This could also be as a result of an uneven temperature distribution within the sample (Mahapatraet al.2010) or presence of ice crystals within the sample (Marchello et al. 1999)). A linear regression wasrunned between temperature and resistivity at

different temperatures for both maximum and minimum values with a very high R^2 of 93.9% and 94.5% for Irvingiagabonensis while 98.6% and 96.3% forMucunaFlagellipes respectively.

3.2 Effects of Temperature on Electrical Conductivity of IrvingiaGabonensis and MucunaFlagellipes

The effect of temperature on electrical conductivity of Irvingiagabonensis and Mucunaflagellipes at 20^0F-50^0F as shown in figure 5 and 6.The conductivity increases with increase in temperature.Electrical conductivity is a measure of how well a material accommodates the movement of electric charge. It is a ratio of the current density to the electric field strength. Also, electrical conductivity is a very useful property since values are affected by such things as substances chemical composition and stress state of the structure. Therefore, electrical conductivity information is useful in sorting of materials, checking proper heat treatment of materials and inspecting of heat damage of material. And these are very useful in the design of the temperature dependent equipment in the processing of biomaterial like ohmic heaters.

3.3 Effects of some physical properties of IrvingiaGabonensis and MucunaFlagellipes on Electrical Conductivity and resistivity

The relationship between some physical properties and moisture content of IrvingiaGabonensis and MucunaFlagellipes at 30^0F (-1.1^{0}C) is presented in table 1 while the relationship between moisture content and Electrical Conductivity and resistivity at 30^0F (-1.1^{0}C) is presented in figure 7 and 8**.**The table and figures showed that although other physical properties like the weight, thickness and diameters of the materials consistently increased with moisture content that cannot be said of the electrical properties. Figure 7 and 8 generally showed that the resistivity of both products decreased at the first stage and started to increase as the moisture content increased. However the reverse was found for the conductivity. According to Mahapatra et.al (2010) level of Moisture present in a bio-material influences sample condition which in turn would have influenced electrical properties.The increase in resistivity and decrease in conductivity was foundto occur for both seeds at moisture contentof about 50%db and above.

4. CONCLUSION

The electrical resistivity and conductivity of irvingiagabonensis (wild mango) and mucunaflagellipeswas determined for a temperature range of 20^0-50^0F. The resistivity and conductivity was not steady showing both minimum and maximum values at different temperatures. On the average the electrical resistivity decreased with increase in temperature while conductivity increased with increase in temperature. Unlike non bio- products the increase or decrease in electrical resistivity and conductivity was inconsistent with the thickness and diameter of the bio- products, however temperature and moisture contents has a more significant effect.

REFERENCE

Abdul A.K 1989. Post harvest losses during processing and preservation of fruits and vegetables. A PhD thesis submitted to university of Punjab Pakistan

Bressani R 2002.Factors influencing nutritive value in food gran legumes.Mucuna compared to other grain legumes. CIDICCO, CIEPCA and World Hunger research center, Tegucigalpa, Honduras (April 26-29, 2000), 164-188.

Cetin. O. and T. Topcu.2009.Effects of electrical stimulation on meat quality.Journal of Food ,Agricultural& Environmental 7(3&4):101-105.una bean.Journal.
Doyle J J 1994, Phylogeny of the legume family: An approach to understanding the origins of nodulation Annual Review of Ecology and Systematics 25:325-349
Ehiem .J.C, K.J.Smonyan.2010.Physical properties of wild mango fruit and nut. International agrophysics vol.24
Grimnes,S and O.G Martinsen 2000.Bioimpedeance and Bioelectricity Basis.SanDiego,CA:Academic press
Icier, F., and T. Baysal. 2004. Dielectric properties of food materials – 1: factors affecting and industrial uses. *Critical Reviews in Food Science and Nutrition* 44: 465-471.
Marchello, M. J., W. D. Slanger, and J. K Carlson. 1999. Bioelectrical impedance: fat content of beef and pork from different size grinds. *Journal of Animal Science* 77: 2464-2468.
Mahapatra ,A .K .C .N. Nguyen, and kannan 2010. Experimental determination of the electrical resistivity of beef. Agricultural Engineering International: the CIGR Ejournal. Manuscript 1664. Vol. XX
Nelson, S.O.1991. Dielectric properties of agricultural products – measurements and applications.CEIDP Digest of Literature on Dielectrics.*IEEE Trans. Electrical Insulation ,26(5):*845–869.
Nelson, S.O. 2000. Sensing moisture content in grain.*IEEE Instrumentation & Measurement Magazine, 31(11):* 17–20.
Nelson, S.O. 2006. Agricultural applications of dielectric measurement.*IEEE Transactions of Dielectric & Electrical Insulation, 13:* 688–702.
Ndukwu M.C. L. Ozoude 2010. Relationship between selected mechanical and Physical properties of mucunaflagellipes (ukpo).With moisture content. Journal of applied Agricultural reasech, Vol.1, p.135
Ranalli G.,M.Lorizzo, G.Lustrato.E. Zanardini,and L.Garzia,2002.Effect of low electric treatment on biomaterial. Journal of Food Technology 93:877-883
Saif. S. M. H. Y. Lan and S. Wang.2004a.Electrical resistivity of chicken meat and pork chop .ASABE Paper No 046030.St SJoseph,Mich.:ASABE
Saif. S. M. H. Y. Lan and S. Wang and S. Garcia 2004b.Electrical resistivity of goat meat. International *Journal of Food Properties* 7 (3): 463-471.
Siddhuraju, P., Vijayakumari, K. and Janardhanan, K. 1995. Studies on the under exploited legume, indigoferalinifolia and sesbariabispmosa: Nutrient Composition and anti-nutritional factors. *International Journal of Food Science and Nutritio*n, 46: 195-203.

Table 1: Average Values of some physical properties of MucunaFlagellipesand IrvingiaGabonensisat 30˚F(-1.1^{0}C)

MucunaFlagellipes				**IrvingiaGabonensis**			
Moisture content (%)db	Average Weight (g)	Average Thickness (mm)	Average Major diameter (mm)	Moisture content (%)db	Average Weight (g)	Average Thickness (mm)	Average Major diameter (mm)
18.7	2.73	2.61	25.25	6.7	1.11	1.55	25.58

27.4	2.93	2.62	26.52	25.9	1.31	1.60	25.78
50.8	3.47	2.92	31.37	35.6	1.41	1.64	26.33
64.8	3.79	3.57	31.60	54.8	1.61	1.84	27.67
65.7	3.81	3.66	31.90	84.6	1.92	3.29	30.50



Fig.1: Mucunaflagellipes seed



Fig 2: Irvingiagabonensis (wild mango) seed

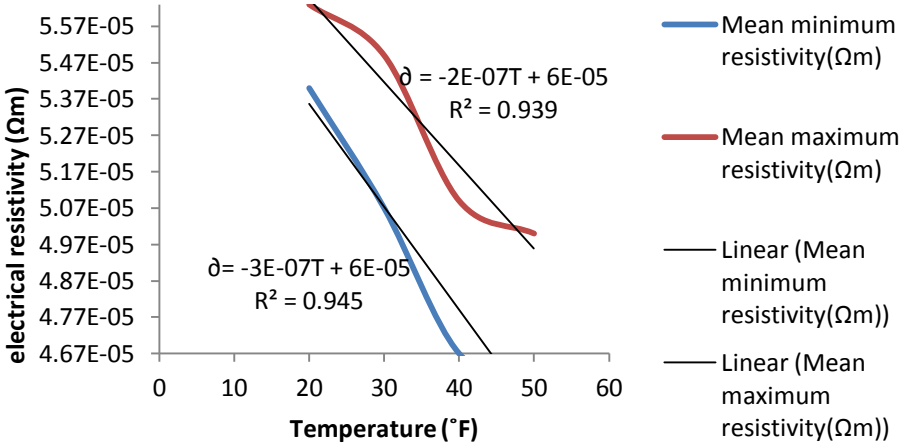


Figure 3.mean value of electrical resistivity at different temperature of Irvingiagabonensis

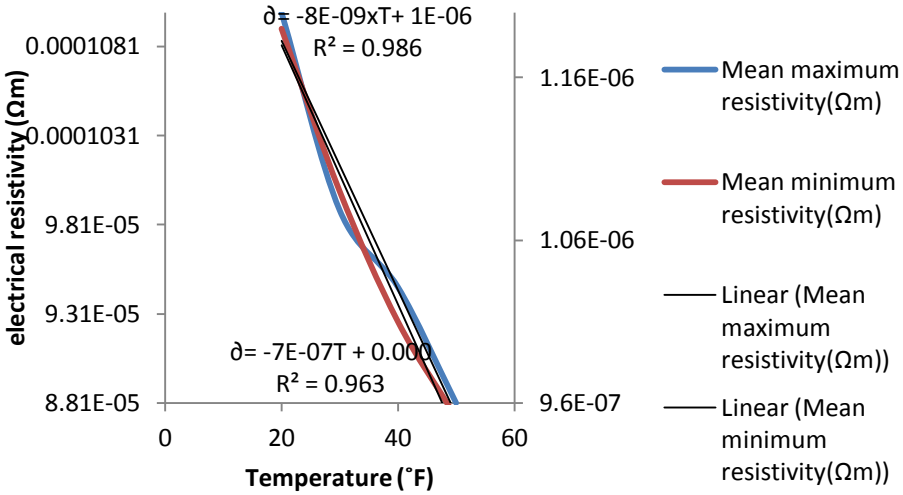


Figure 4: Average mean value of electrical resistivity at different temperature of MucunaFlagellipes

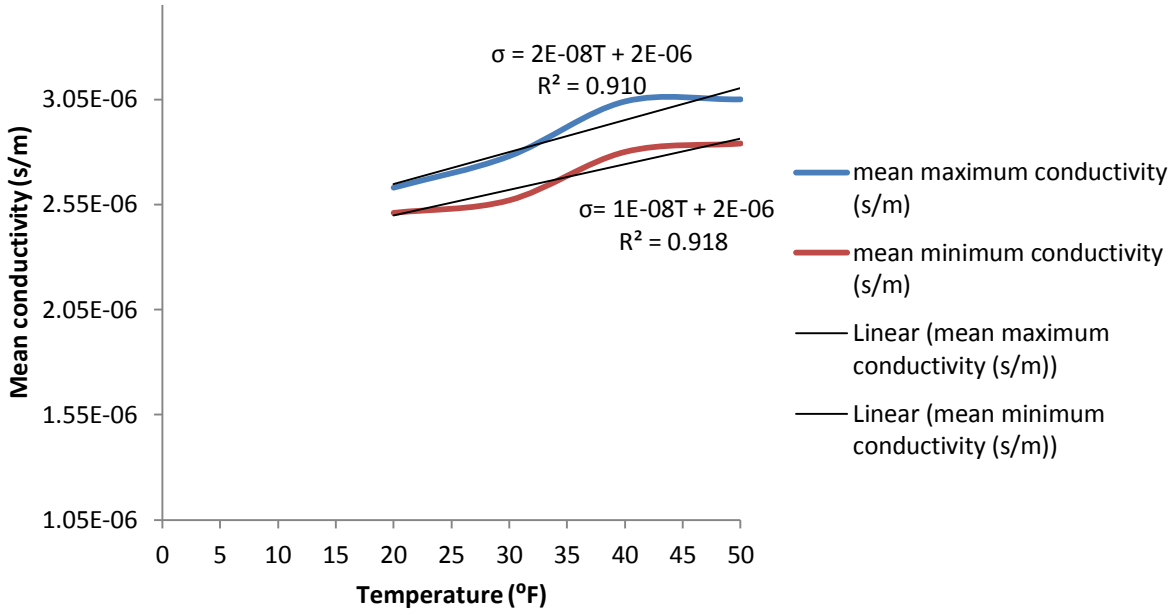


Figure: mean value of electrical conductivity at different temperature of Irvingiagabonensis

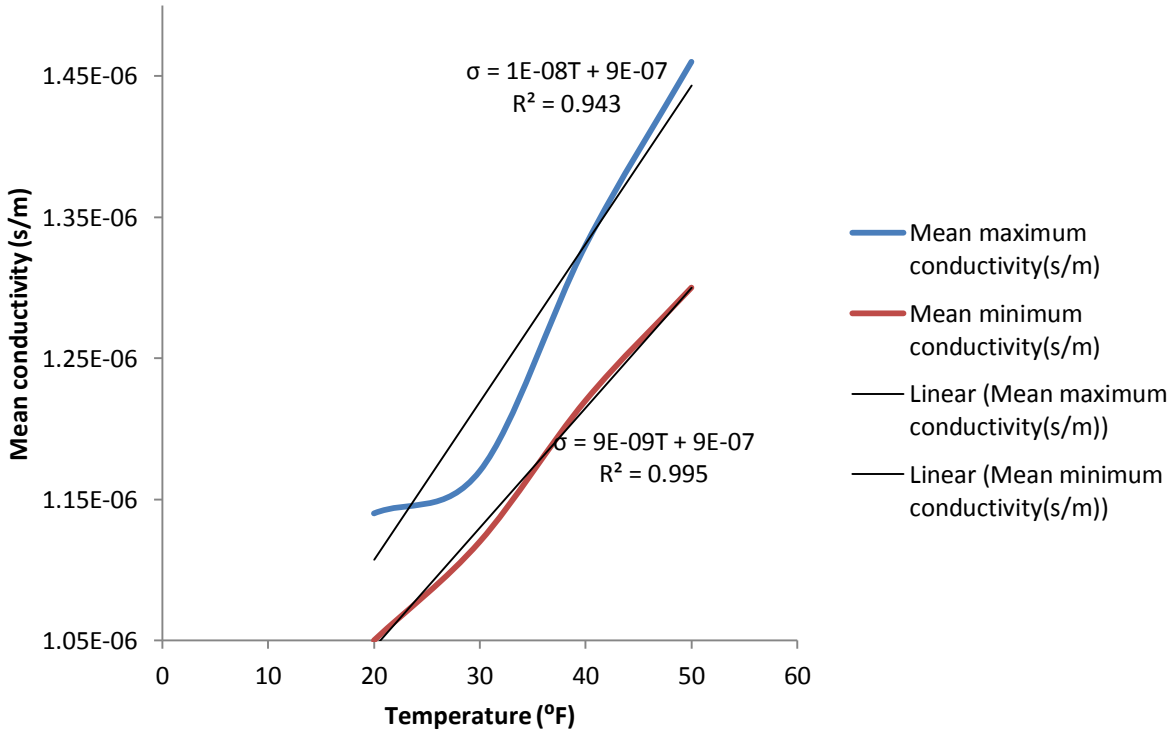


Figure 6: mean value of electrical conductivity at different temperature for MucunaFlagellipes

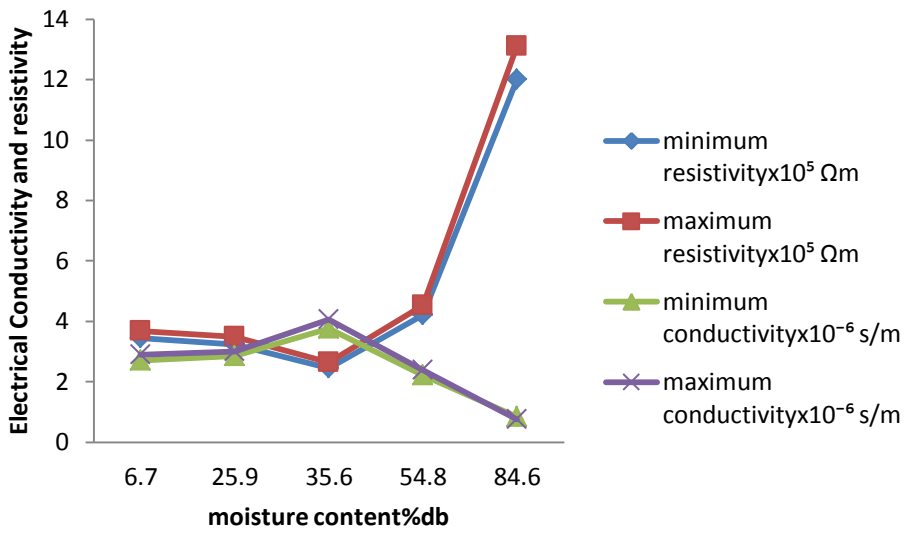


Figure 7: relationship between moisture content and Electrical Conductivity and resistivity of IrvingiaGabonensisat 30^{0}F (-1.1^{0}C)

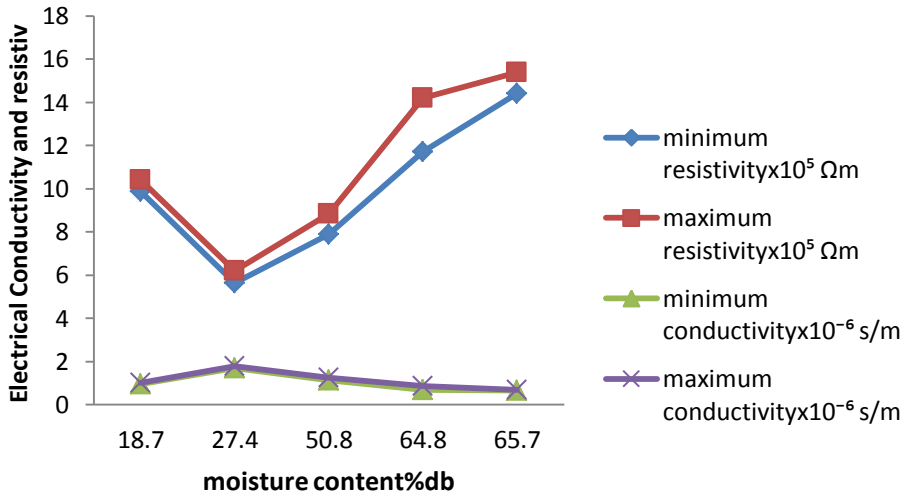


Figure 8: relationship between moisture content and Electrical Conductivity and resistivity of MucunaFlagellipesat 30^{0}F (-1.1^{0}C

EFFECT OF PROCESSING CONDITIONS ON THE WHOLENESS OF CASHEW KERNELS USING STEAM BOILING METHOD

Obi, O. F.,Nwakaire, J. N., Aneke, N. N.,Ezeoha, S. L. and Nwagugu, N. I.

Agricultural and Bioresources Engineering Department, University of Nigeria, Nsukka, Nigeria
francis.obi@unn.edu.ng ;joel.nwakaire@unn.edu.ng

ABSTRACT

An investigation was carried out on the effect of processing conditions such as steam exposure time and cooling duration on the wholeness of cashew kernel using large and small cashew nuts. Cashew nuts were collected, cleaned and sorted into large and small sizes based on visual observation. The cashew nuts were divided into four different parts of 1 kg each and were steamed in an autoclave for 28, 30, 32, and 34 minutes respectively. Each of the 1 kg parts was further divided into three equal parts and cooled for 12, 18 and 24 hrs respectively. The results showed that both steam exposure time and cooling duration had a significant effect on the wholeness of cashew kernel on both large and small cashew nuts. However, no significant difference was observed on the wholeness (percentage of whole and broken kernels) of large cashew kernel yield at 18 hours of cooling duration andvarying steam exposure periods of 28, 30, 32, and 34 minutes. Likewise, no significant difference was observed on the percentage of whole kernels recovered at 24 hours of cooling duration from the small cashew nuts. The optimum processing condition for large cashew nuts was a combination of 34 minutes of steam exposure time and 12 hours of cooling duration, which gave 75.3% yield of whole kernels. And for the small cashew nuts, a combination of 30 minutes of steam exposure time and 24 hours of cooling duration which gave a whole kernel yield of 77.3%.

Keywords: Cashew nuts, Processing conditions, Kernels, Steam boiling

1.0 Introduction

Cashew (*Anarcardiumoccidentale*) is a resilient and fast growing evergreen tree, which can grow to a height of about 20 meters. Cashew tree thrives on a variety of soils with minimum care and is resistant to adverse climatic conditions wherein several other commercial crops will not survive (Laurent and Russel, 1968). It reaches full bearing age after three years and may continue yielding for over forty years(Davis, 1999).An average annual yield from mature cashew tree is variable from a few kilos to 100 kg (Ohler, 1978).The nut (a fruit seed enclosed in a woodycovering - the pericarp) is attached to the end of the fruit of cashew tree (Ranken and Kill, 1993). A thin, tannin-rich testa surrounds the kernel and keeps it separated from the shell inside its internal cavity. The kernel is made up of two kidney shaped cotyledons and embryo. At maturity, cashew nuts are usually ash-green or grayish—brown in colour and it is about 3 – 7 cm long and weighs 4 – 16 g (Agnoloni and Giuliani, 1977;Andrighetti*et al.,*). The kernel accounts for about 22% – 24% of the whole nut at processing (Andrighetti*et al.,*)

At maturity, cashew nuts are generally allowed to fall to the ground before they are collected to ensure that the kernel is mature. Immediately after harvest, cashew nuts are sun dried for few days until they have moisture content between 8% - 12% or until the kernel is heard rattling inside the nut (Rivoira*et al.,* 1998) to prevent the deterioration of the kernel. The processing of

cashew nuts involves material separation in the unit operations of nut conditioning, shelling, kernel drying, peeling and packaging. There are different methods of processing cashew nut one of which is the steam boiling method. In this method, the nuts are traditionally boiled in a large cauldron and then sun dried before shelling which makes it easier to separate the nut from the shell. A specially designed steam boiler, autoclave, is now being employed for the steam boiling operation. The raw cashew nuts are boiled in an autoclave, spread onto the floor to cool and dried in natural air after which it is shelled. The cooking of the nuts in steam renders white kernels and increases the number of whole kernels recovered which gets a premium in the export market. Cashew kernels are broadly classified into whole and broken kernels according to (Rosengarten, 1984). Whole kernels are kernels of characteristic shape with no more than one eighth of the kernel broken off while broken kernels are kernels with more than one eighth of the original kernel broken off.

There has been a growing demand for cashew in many temperate countries (UNECE) due to its very high utility value; and among horticultural crops, cashew has been found to provide very high economic returns, especially because of its foreign exchange earning potential. Nigeria however, has not been able to tap into the international market for cashew kernel due to the constraint faced in producing whole kernels for export. This required quality of cashew kernels for export is determined by the processing conditions to which the nuts are subjected. Hence there is the need to investigate the interaction between the pre-shelling conditions of steam exposure time and cooling duration on the wholeness of cashew kernels recovered after nut conditioning.

2.0 MATERIALS AND METHODS

The study was carried out at the Federal Institute of Industrial Research,Oshodi (FIRRO), Lagos, Nigeria.

2.1 Materials

About 10kg of sun dried cashew nuts obtained from Cashew Nut Plantation,Iwo (CANPI) in Osun state, Nigeria, sorted into large and small sizes based on visual observation; a laboratory autoclave for cashew nut conditioning;a hand-operated mechanical cashew nut shelling machine; an electronic weighing machine; a Gallenkamp 300 plus series oven for moisture content determination; and a hacksaw blade for separating the kernels from the nuts.

2.2 Moisture Content Determination

The moisture content (dry basis) of the cashew nut shell and the kernelbefore conditioning were determined according to (Russel,1979) after dividing some randomly selected nuts along their line of cleavage to separate the shell from the kernel. The following equation was applied to obtain the moisture contents:

$$\boldsymbol{MC_{db}} = \frac{\boldsymbol{mb-ma}}{\boldsymbol{ma-mc}} \times \mathbf{100} \qquad (1)$$

Where,
$\boldsymbol{MC_{db}}$= Moisture content (dry basis)
$\boldsymbol{mb}$= Weight of moisture can + sample weight before heating
$\boldsymbol{ma}$= Weight of moisture can + sample weight after heating
$\boldsymbol{mc}$= Weight of moisture can

2.3 Cashew Nut Conditioning

About 1 kg each of randomly selected large cashew nuts weresteam boiled in an autoclave at a temperature of 120^{o}C and pressure of 125 PSI for 28, 30, 32 and 34 minutes respectively. Each of the 1 kg cashew nuts was divided into three parts of about the same weight and cooled at ambient temperature for 12, 18 and 24 hours respectivelyafter which they were shelled. The shelled nuts were separated from the kernels, sorted into whole and broken kernels and then weighed. The percentage weight of whole and broken kernels was calculated.The same experimental procedure was carried out on the small cashew nuts.The experiment was replicated thrice.

2.4 Statistical Analysis

The data obtained were subjected to Analysis of Variance (ANOVA) using Statistical Analytical Software, 2000 and the means separated using Duncan's Multiple Range Test.

3.0 RESULTS AND DISCUSSIONS

The moisture content of the cashew nut shell before processing was 16.84% (dry basis) and that of the kernel was 13.30% (dry basis). The mean percentage weight of whole and broken kernels recovered from large and small cashew nuts under different combinations of steam exposure time and cooling duration are shown in **Tables 1** and **2**.**Figures 1**and**2**show the percentages of whole and broken kernelsrecovered from large and small cashew nuts at different cooling durations of (a) 12hours (b) 18 and (c) 24 hours, and at varying steam exposure times of 28, 30, 32 and 34 minutes respectively.Table 1 shows that for the large cashew nuts, steam exposure time and cooling duration both had a significant effect ($P < 0.05$) on the wholeness (whole and broken kernels) of the kernels recovered after shelling, except at 18 hours of cooling time, where there were no significant difference in percentages of whole and broken kernels recovered at varying steam exposure times. Unlikein other cooling durations, the percentages of whole kernels recovered at 24 hours of cooling duration were all significantly different from one another.Steaming for 34 minutes and cooling for 12 hours gave the optimum processing conditions for large cashew nuts with a whole kernel yield of 75.3% and broken kernel yield of 24.7%.

Table 2 shows that for the small cashew nuts, steam exposure time and cooling duration had a significant effect ($P< 0.05$) on the wholeness (whole and broken kernels) of the kernels recovered after shelling except at 12 and 24 hours of cooling duration where there were no significant difference in the percentages of broken and whole kernels, respectively. At 12 hours of cooling duration however, there was a significant difference in the percentage of whole kernels recovered. Steaming for 30 minutes and cooling for 24 hours gave the optimum processing conditions for small cashew nuts with a whole kernelyield of 77.3% and broken kernel yield of 22.7% (**Table 2**).The yields obtained at the optimum processing conditions for large and small cashew nut meet the industry'srequirement of 75% – 80% whole kernel yield for profitable production (AOAC, 1984). (HORUS, 2005) reported that the optimum processing conditions that gave a 97% of grade 1 Gorgon nut kernels were a combination of first roasting of dried nut (moisture content 33% dry basis) at 335°C for 3·9 minutes, tempering for 23 hours and second roasting at 335°C for 2·8 minutes. These conditions reduced the processing time to less than one-half as compared with the traditional method.

Table 1: Post-Shelling Data for Large Cashew Nuts

Kernel Yield	Cooling Duration (hrs)	Steam Exposure Time (min) 28	30	32	34
Whole Kernel (%)	12	72.1[b]	65.0[a,b]	55.4[b]	75.3[a]
	18	71.9[a]	73.1[a]	61.3[a]	72.8[a]
	24	42.6[c]	74.6[a]	32.8[d]	66.0[b]
Broken Kernel (%)	12	27.9[c]	35.0[a,b]	44.6[a]	24.7[b,c]
	18	28.1[a]	26.9[a]	38.7[a]	27.2[a]
	24	57.4[a]	25.4[b]	67.2[a,b]	34.0[b]

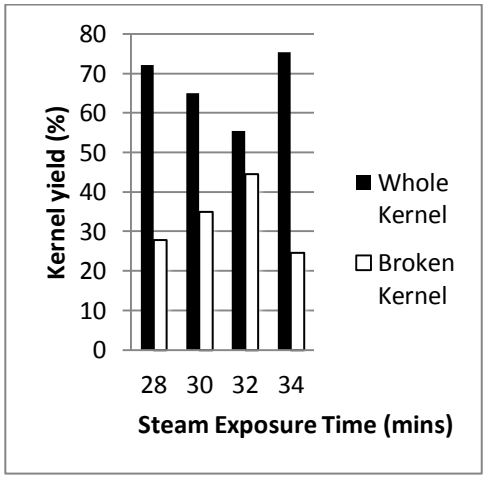
Values are means of three replicates.
Means with the same letter across a row are not significantly different ($P < 0.05$)

Table 2: Post-Shelling Data for Small Cashew Nuts

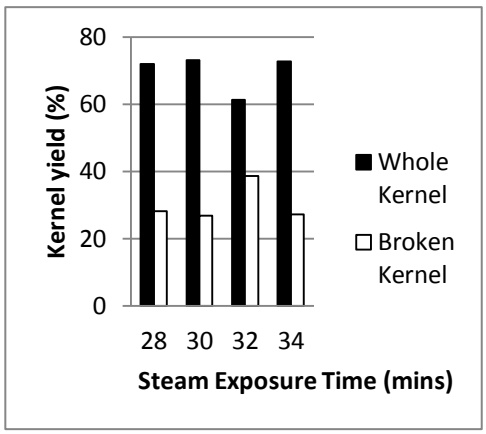
Kernel Yield	Cooling Duration (hrs)	Steam Exposure Time (min) 28	30	32	34
Whole Kernel (%)	12	55.9[b]	62.9[a]	65.3[c]	39.2[d]
	18	65.9[a]	55.0[b]	63.0[b]	57.2[b]
	24	76.4[a]	77.3[a]	58.0[a]	63.1[a]
Broken Kernel (%)	12	44.1[a]	37.1[a]	34.7[a]	60.8[a]
	18	34.1[a,b]	45.0[a]	37.0[b]	42.8[a,b]
	24	23.6[c]	22.7[b,c]	42.0[a]	36.9[a,b]

Values are means of three replicates.
Means with the same letter across a row are not significantly different ($P < 0.05$)

(a)(



(b)(



(c)

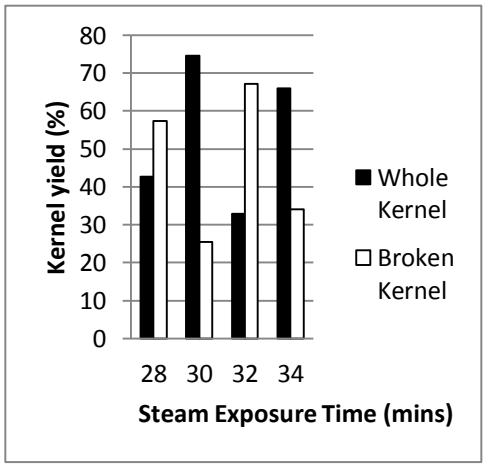
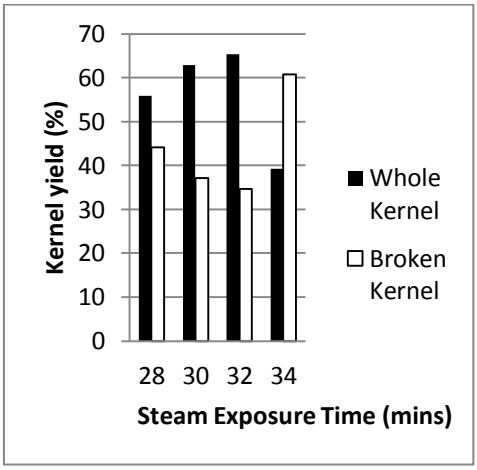
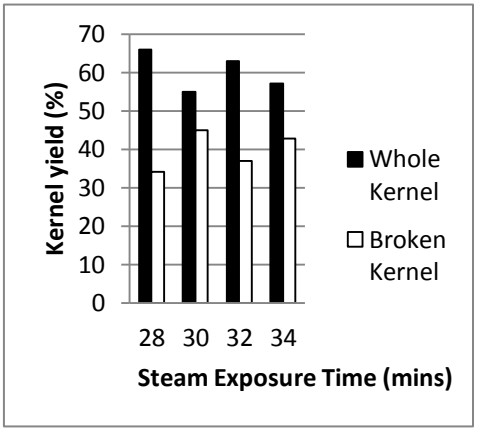


Figure 1: Wholesomeness of Large Cashew Kernel Yield at (a) 12 hrs (b) 18 hrs and (c) 24 hrs of Cooling Duration and at Varying Steam Exposure Times of 28, 30, 32 and 34 Minutes.

(a)(



(b)



(c)(

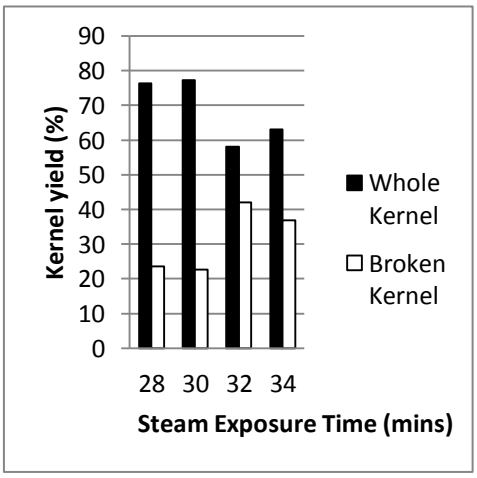


Figure 2: Wholesomeness of Small Cashew Kernel Yield at (a) 12 hrs (b) 18 hrs and (c) 24 hrs of Cooling Duration and at Varying Steam Exposure Times of 28, 30, 32 and 34 Minutes.

4.0 CONCLUSION

1. Pre-shelling conditions of steam exposure time and cooling duration of large and small cashew nuts both have a significant effect on the wholeness of cashew kernels recovered after shelling.
2. Steaming for 34 minutes and cooling for 12 hours gave the highest percentage of whole kernels for large cashew nuts and steaming for 30 minutes and cooling for 24 hours gave the highest percentage of whole kernels for small cashew nuts.
3. These optimum processing conditions should be adopted in large scale cashew kernel production in Nigeria for profitable yield of whole cashew kernels for foreign markets.

REFERENCES

Agnoloni A. and Giuliani F., Cashew Nut Cultivation. Ministry of Foreign Affairs, InstitutoAgronomico per Oltremare, Italy, 1977.

Andrighetti L., Bassi G. F., Capella P. A. M., Deolalikar A. B., Haesusler G., Malorgio G. A., Franca

AOAC, Official methods of analysis.Association of Analytical Chemist.14th edition, Washington DC, 1984.

Davis K., Cashew. ECHO Technical Note. Issue 32, 1999, pp. 7 – 8.

F. M. C., Rivoira G., Vannini L., and Deserti R., The world cashew economy.Linchiostroblu, Italy, 1998, pp. 35- 36.

HORUS Enterprises, Long term trends in the international cashew market and strategic implications for Sub-Saharan African exporters. Final report, 2005.

Jha S. N. and Prasad S., Determination of processing conditions for Gorgon nut (Euryale ferox). Journal of Agricultural Engineering ResearchVolume 63, Issue 2, 1996, Pages 103-111.

Laurent K. and Russell D. C., **Cashew production, processing, and marketing in Nigeria.**Published by Consortium for the Study of Nigerian Rural Development, Michigan State University, East Lansing, 1968.

Ohler J.G., Cashew Growing: Tropical Abstracts. Cashew Dept. Agric. Res., Royal Tropical Institute Press, Amsterdam, 1979.

Ranken M. D., Kill R. C., Food industries manual. 23rd edition, Blackie academic and professional and imprint of Chapman and Hall, 1993, Pp. 406 - 408.

Rosengarten F. Jr., The Book of Edible Nuts. Walker and Company, New York, 1984.

Russel, Cashew nut Processing.FAO Agricultural Services Bulletin. Third Ed. FAO, Rome,1979.

UNECE Standard DF-17.Concerning the marketing and commercial quality control of cashew kernels moving in international trade between and to UNECE member countries.

SOME STUDIES ON THE DRYING OF DIKA NUT

Aneke, N. N., Obi, O. F. and Nwakaire, J. N.

Agricultural and Bioresources Engineering Department, University of Nigeria, Nsukka.francis.obi2010@gmail.com

ABSTRACT

Dika nut is a very important food crop in West and Central Africa hence, if it is not dried well, the kernels would perish when it is being stored. A thorough knowledge of the nutrient composition of food crops as affected by artificial drying method is very important for storage and preservation. The effect of different drying temperatures on the proximate and mineral compositions of dika kernels was investigated. Dika nut samples were obtained from a local market in South Western Nigeria. The drying temperatures used were 50^{o}C, 60^{o}C, 70^{o}C and 80^{o}C. The results showed that some artificially dried kernels had better nutritive quality than the sun dried kernels depending on the parameters considered. Also using mineral composition as a basis, kernels dried at 80^{o}C after shelling gave the optimum result.

Keywords: Dika nuts, drying, optimum temperature, kernels

1.0 Introduction

Dika fruit (Figure 1), a mango-like, large, edible, drupe with a thick fibrous flesh is widely grown in Central and West Africa and it thrives best in evergreen and semi deciduous forest.Akubor (1996) reported that the extraction rate of juice from the fruit pulp is 75% and the sugar concentration of this juice is comparable with pineapples and oranges but with a higher ascorbic acid content (67mg/100ml). The kernel which is obtainable after shellingthe nut is the most important part of the dika tree. Dikakernel commonly called *ogbono* by the Ibos of South-East Nigeria and *aapon* by the Yorubas of South-West Nigeria is basically used as a thickening agent in soups and stews in these parts of Nigeria. Dika. The demand of *Irvingiagabonensis* in southern Nigeria has been estimated at 80,000 tons per year (Leakey and Maghembe, undated) making it a nut with high economic prospects in the sub-Saharan Africa. Drying and storage of dika kernels, however, is a major challenge faced by dika nut processors in West and Central Africa. This may be due to the weather condition not being favourable and also due to too much material handling of the kernels during drying which might lead to spoilage. The objectives of this work are to determine theeffect of drying temperature on the proximate and mineral composition of artificially dried dika kernels; and to determine the optimum drying temperature for artificially dryied of dika kernels comparable to sun dried kernels.This work is intended to aid food processing industries in determining the best way of drying dika kernels artificially and at the same time retain the nutritive value as the naturally dried kernels.



Figure 1(a): Dika fruit **(b):** Dried dika fruit **(c):**Dika kernel

Giner and Gely (2005) conducted some drying studies on sunflower seeds. They measured and analyzed the sorption characteristics of sunflower seeds to provide a means for evaluating stability conditions preventing microbial spoilage and oil acidification. Sacilik and Unal (2005)conducted a study to investigate the dehydration characteristics of Kastamonu garlic (*Allium sativumL.*) in a convective hot-air dryer. They examined the dehydration characteristics of garlic slices at air temperatures of 40, 50 and 60 °C and sample thicknesses of 3 and 5 mm. The effects of air temperature and sample thickness on the dehydration characteristics and quality parameters of the dehydrated garlic slices were determined. Doymaz*et al* (2005) conducted experiments on the drying of dill and parsley leaves. The drying of dill and parsley leaves was investigated in a laboratory dryer. They studied the effect of temperature on drying rate of samples at constant air velocity (1.1 m/s) and various temperatures (50, 60 and 70 °C). The effective diffusivity values changed from 6.693×10^{-10} to 1.434×10^{-9} m^2/s and 9.0×10^{-10} to 2.337×10^{-9} m^2/s for dill and parsley leaves, respectively, within the given temperature range. Mwithiga and Olwal (2004) investigated the effect of air temperature and sample thickness on the drying kinetics of kale using a convective air dryer at a fixed airflow rate of 1 m/s and drying air temperatures of 30, 40, 50 and 60 °C. The sliced kale leaves were dried in wire trays in 10, 20, 40 and 50 mm thick layers. The drying rate increased with drying air temperature but decreased with layer thickness.

2.0 MATERIALS AND METHODS

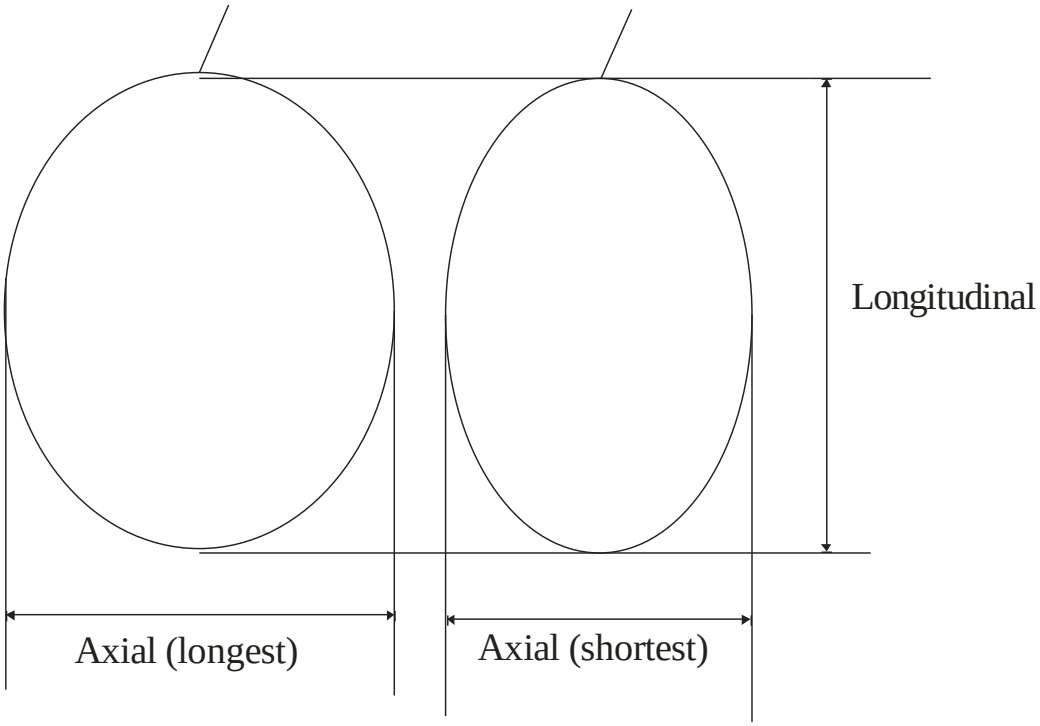
2.1Materials

Fresh dika fruits were obtained from Sabo market in Ile-Ife, Osun State. The pulp of the fruit waspeeled off the nuts and some of the nuts were cracked to obtain the kernel.The equipment used for the experimentincludes an electric oven (the Gallenkamp oven 300plus series), digital weighing machine (Mettler Toledo), vernier calliper and micrometer screw gauge, and an atomic absorption spectrophotometer.

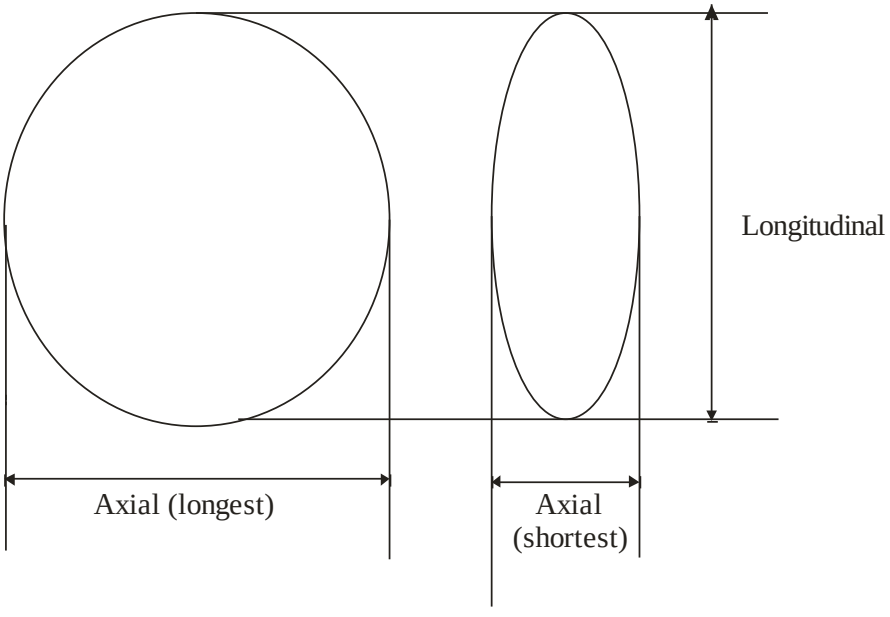
2.2 Methods

2.2.1 Determination of physical properties

The physical dimensions (Figure 2(a) and (b)) and masses of the dika fruit and nuts were measured using a vernier calliper and an electronic weighing balance respectively.



(a)



(b)

Figure 2: Physical dimensions of dika fruit and nuts

2.2.2 Determination of moisture content

Moisture content determination was carried out usingASAE standards (1997). The moisture content of the nut and the kernels were determined in replicates of three.Six containers labelled A to F were weighed and then three of them were used for the nuts and the other three were used for the kernels. Whole nuts (10g)were weighed (M_i) in triplicates and placed in containers. These samples were introduced into a mechanical convection oven set at 130^{o}C for six hours.After the six hours, the samples were removed and placed in desiccators to cool and then the weights were taken again (M_f). The moisture contentswere determined using the following equation.

$$\text{MC wet basis} = \frac{M_i - M_f}{M_i} \text{ x } 100 \quad (1)$$

$$\text{MC dry basis} = \frac{M_i - M_f}{M_f} \text{ x } 100 \quad (2)$$

Where M_i = Initial mass of the sample

M_f = Final mass of the sample

MC = Moisture content

2.2.3Drying of the dika nut and kernels

Four different oven temperatures (50, 60, 70 and 80^{o}C)were used to dry the nuts and kernels in thin layer to simulate sun drying. Dika nut samples in triplicates weighing about 30g and dika kernels samples also in triplicates weighing about15g were oven dried at the different temperaturesof 50, 60, 70 and 80^{o}C. The weight of the samples were taken at 10 minutes interval for the first one hour, then the weight of the samples were taken at 20 minutes interval for the next 2 hours, 40 minutes for 2 hours, then 1 hour for 3 hours,2 hours for 10 hours and then 3hours interval till the weight stabilized. The drying curves were then plotted for different temperatures.

2.2.4 Proximate analysis

The proximate analysis of dika kernels was carried out in the Department of Animal Science, Obafemi Awolowo University, Ile-Ife. The tests involve the determination of the percentage compositions of ash, crude fibre, crude protein, nitrogen and oil. The tests were carried out in triplicates.

(a)**Determination of percentage ash**

About two grams of the dika kernels was placed in a crucible and weighed (W_i). It was then heated in a furnace at 600^{o}C – 650^{o}C for three hours and then reweighed (W_f) (Ogunyemi, 2007).

$$\% \text{ Ash} = \frac{100(W_i - W_f)}{2g} \quad (3)$$

(b) **Determination of percentage crude protein.**

In determining the percentage crude protein, the sampleswere taken through three distinct processes: digestion, distillation and titration (Ogunyemi, 2007). In the digestion stage, about two grams of grounded sample was put into a digestion flask. Sufficient quantity of a digestion mixture (consists of copper sulphate, selenium (catalysts) and sodium or potassium sulphate to raise the boiling point) and 20ml - 30ml of concentrated sulphuric acid was added to the sample. The mixture was digested for three hours using the Tecator Digestion System 1007 Digester (Ogunyemi, 2007).The product of digestion was diluted to 50ml with water. Boric acid (mixed with methyl red and brooms green)was poured into a 250ml Pyrex flask measuring 2% of the 50ml of the diluted digestion product. Sodium hydroxide, 40% of 50mlwas added to 20ml of the diluted sample. The digestion tube and Pyrex flask were placed in the distillation unit (with the Pyrex flask under the receiving tube). The distillation process was then activated until the total content of the Pyrex flask was about 100ml (Ogunyemi, 2007). The distillate was titrated with 0.097ml of HCL until the green colour disappears. The net volume of acid (v) used was noted (Ogunyemi, 2007).

$$\%\text{Nitrogen} = \frac{v \times 0.097 \times 14 \times 100 \times 2.5}{2g} \quad (4)$$

Molar mass of Nitrogen =14

$$\% \text{ crude protein} = 6.25 \times \% \text{ Nitrogen} \quad (5)$$

(c) Determination of crude fibre:

About 2g of sample was transferred into a 500 ml conical flask. 100ml of digestion reagent was added to the flask and then boiled as rapidly as possible. The heat was turned down and allowed to simmer under reflux for exactly 40 minutes from first adding the reagent using an air condenser consisting of a glass long fitted in a rubber bung. The content of the flask was swirled from time to time to ensure even digestion. The flask was removed and cooled under a cold water tap. The contents was filtered through a 15cm What man No. 4 paper and washed six times with hot water and then once with industrial spirit. The paper was opened and all the contents was transferred into a flat bottomed porcelain dish by means of a spatula. The residue was dried for two hours at 100^{o}C and then cooled for 3 minutes in a desiccator and weighed. The residue was burnt in a muffle furnace at 600^{o}C for 30 minutes then cooled in a desiccator and reweighed (Ogunyemi, 2007).

$$\%\text{Crude fibre} = \frac{W_l \times 100}{W_s} \quad (6)$$

Where W_l= Weight loss on ashing
W_s = Weight of sample

(d) **Determination of ether extract**
The apparatus consists of a soxhlet extractor, a condenser and a small flask of known weight (W_i). About 2 grams of the sample was put into a fat-free thimble, sealed with cotton wool and placed in the extractor. Hexane was then added until the barrel of the extractor was half full and the set-up is heated for 3 hours. The flask (now contains the oil) was detached and weighed (W_f) (Ogunyemi, 2007).

$$\%oil = \frac{100(w_i - w_f)}{2g} \quad (7)$$

(e) Determination of total carbohydrate:
Total carbohydrate was calculated as the sum of nitrogen free extract and crude fiber. The Nitrogen free extract (NFE) was calculated as shown in the equation below (Ogunyemi, 2007).

NFE = 100-(% moisture + % ash +% crude fibre + % crudeprotein + % etherextract)

Total carbohydrate= %N.F.E + %Crude fiber (8)

2.2.5Mineral analysis
Some prominent minerals which were determined include calcium, magnesium, potassium and phosphorus. This analysis was done at the Central Science Laboratory, Obafemi Awolowo University. Ile-Ife. About 2g of the dika kernels were placed in a platinum crucible, ashing at 600oC for 3 hours in a muffle furnace. The sample was removed and allowed to cool in a desiccator. After cooling, 5ml of 6N HCL was added to the sample. The sample was left for 30 minutes to dissolve and filtered into a 50ml volumetric flask, made up to 50ml with distilled water and vigorously shaken. Each mineral was read with atomic adsorption spectrophotometer (AAS) at different wavelengths.

2.2.6 Statistical analysis
The results obtained from the proximate and mineral analysis of the dika kernels were analyzed statistically using Statistical Analysis Software (SAS).

3.0 RESULTS AND DISCUSSIONS

3.1Physical Properties of Dika Fruits and Nuts

The moisture content of the dika nut and kernel were determined to be 41.79% (wet basis) and 40.32% (wet basis) respectively. The average physical dimensions of the dika fruits and nuts are shown in the Table 4.1.

Table 4.1: Mean physical dimensions of dika fruits and nuts

	Longitudinal (cm)	Axial (Longest) (cm)	Axial (Shortest) (cm)	Equivalent Diameter (cm)	Mass (g)
Fruits	6.5982 (0.4541)	6.0756 (0.3227)	5.6074 (0.3428)	6.0749 (0.2728)	135.3468 (17.3342)
Nuts	4.4143 (0.3725)	3.1595 (0.2301)	2.1438 (0.1422)	3.0994 (0.1608)	18.0696 (2.7685)

Values in parenthesis are standard deviation

3.2 Drying Results

3.2.1 Drying of dika kernels

Drying of an agricultural product is usually in two stages: the constant rate period and the falling rate period. During the constant rate period, water usually evaporates freely from the surface of the material and the equation of heat and mass transfer is applicable. During the falling rate period, the rate of drying decreases continuously and prolonged drying times are needed for the material to attain a low moisture content considered favourable for storage. The times required to dry the kernels at 50, 60, 70 and 80^{o}C were obtained as 1620, 1440, 1260 and 840 minutes respectively. At 50^{o}C, the constant rate period occurred between 15 and 70% moisture content (dry basis) and the falling rate occurred between 0 and 15% moisture content (dry basis) thereby having 15% as the critical moisture content. At 60^{o}C, the constant rate period occurred between 10 and 70% moisture content (dry basis) and the falling rate occurred between 0 and 10% moisture content (dry basis) thereby having 10% as the critical moisture content. At 70^{o}C, the constant rate period occurred between 5 and 70% moisture content (dry basis) and the falling rate period occurred between 0 and 5% moisture content (dry basis) thereby having 5% as the critical moisture content. At 80^{o}C the constant rate period occurred between 8 and 70% moisture content (dry basis) and the falling rate period occurred between 0 and 8% moisture content (dry basis) thereby having 8% as the critical moisture content. The moisture contents (dry basis) of the kernels at different time intervals for each drying temperature are shown in the Table 4.2 and the drying curves are shown Figure 3.

Table 4.2:Moisture content % (db) of dika kernels at different temperatures

Time (mins)	50^{o}C	60^{o}C	70^{o}C	80^{o}C
0	70.58%	69.86%	71.06%	68.76%
10	60.99%	59.81%	60.91%	57.90%
20	53.01%	51.99%	51.80%	47.82%
30	47.19%	45.66%	43.58%	39.93%
40	42.16%	41.17%	37.08%	33.74%
50	37.89%	37.22%	31.72%	28.76%
60	34.09%	34.19%	27.21%	24.64%
80	29.13%	28.30%	21.19%	18.89%
100	25.02%	23.11%	16.61%	14.70%
120	21.81%	18.81%	13.15%	11.63%

Time (mins)	50°C	60°C	70°C	80°C
140	19.14%	15.42%	10.62%	9.52%
160	16.91%	12.88%	7.58%	8.02%
180	15.11%	11.03%	5.46%	6.88%
220	12.75%	8.16%	3.75%	5.03%
260	10.86%	6.30%	2.91%	3.90%
300	9.11%	5.00%	2.25%	3.24%
360	6.71%	3.44%	1.60%	1.93%
420	5.11%	2.35%	1.18%	1.07%
480	3.69%	1.25%	0.86%	0.39%
600	2.29%	0.61%	0.46%	0.08%
720	1.22%	0.24%	0.23%	0.01%
840	0.58%	0.09%	0.09%	0.00%
960	0.26%	0.03%	0.03%	
1080	0.06%	0.00%	0.00%	
1260	0.01%	0.00%	0.00%	
1440	0.00%	0.00%		
1620	0.00%			

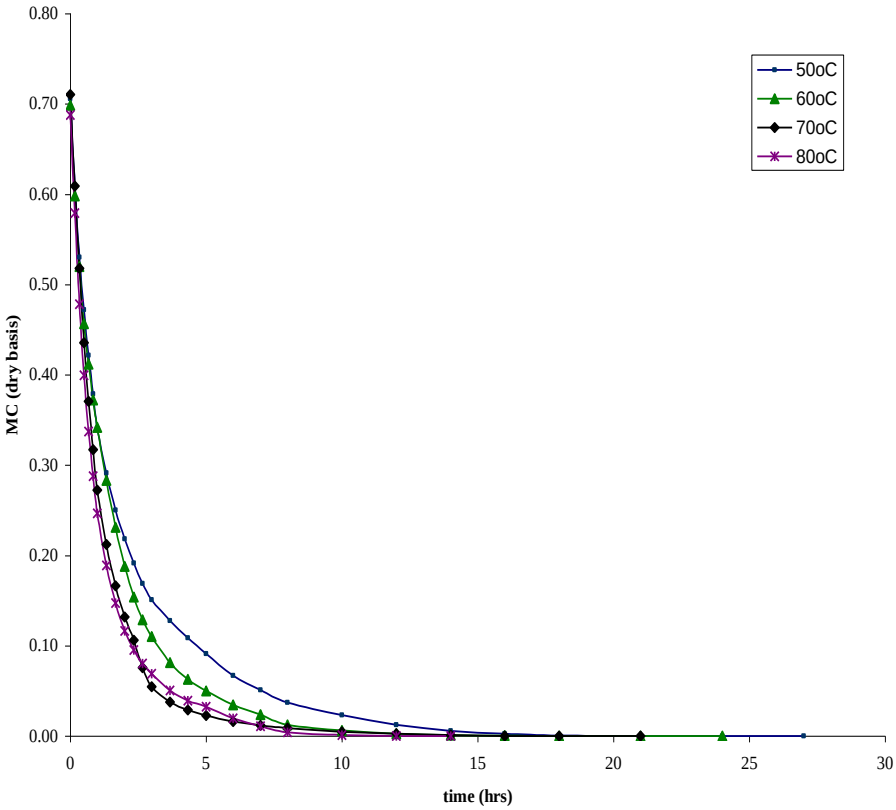


Fig 4.1: Drying curves for dika kernels at 4 temperature levels

3.2.2 Drying of dika nuts

The moisture content (dry basis) of the nuts at different time intervals for each drying temperature is shown in the Table 4.3. At 50^{o}C, the constant rate period occurred between 20 and 73% moisture content (dry basis) and the falling rate occurred between 0 and 20% moisture content (dry basis) thereby having 20% as the critical moisture content. At 60^{o}C, the constant rate period occurred between 17 and 73% moisture content (dry basis) and the falling rate occurred between 0 and 17% moisture content (dry basis) thereby having 17% as the critical moisture content. At 70^{o}C, the constant rate period occurred between 15 and 74% moisture content (dry basis) and the falling rate period occurred between 0 and 15% moisture content (dry basis) thereby having 15% as the critical moisture content. At 80^{o}C the constant rate period occurred between 9 and 71% moisture content (dry basis) and the falling rate period occurred between 0 and 9% moisture content (dry basis) thereby having 9% as the critical moisture content.

Table 4.3: Moisture content % (db) of dika nut at different temp.

Time (mins)	50^{o}C	60^{o}C	70^{o}C	80^{o}C
0	72.93%	67.59%	74.34%	71.87%
10	69.82%	64.13%	70.29%	67.22%
20	66.21%	58.48%	65.61%	62.22%
30	62.67%	53.77%	60.22%	57.39%
40	59.23%	49.67%	55.69%	52.71%
50	55.93%	46.16%	51.19%	48.65%
60	52.74%	43.19%	47.22%	45.13%
80	46.64%	40.48%	40.48%	40.32%
100	41.17%	36.57%	35.26%	36.28%
120	36.56%	33.08%	31.06%	32.76%
140	32.50%	30.08%	27.75%	29.96%
160	29.56%	27.65%	24.34%	27.50%
180	26.97%	25.61%	22.24%	25.31%
220	23.15%	23.76%	18.75%	21.92%
260	20.25%	20.95%	16.41%	18.88%
300	17.80%	18.52%	14.60%	16.32%
360	14.93%	16.37%	12.20%	12.35%
420	12.83%	13.01%	10.16%	9.17%
480	11.07%	10.13%	9.12%	6.74%
600	81.4%	7.76%	6.42%	3.31%
720	5.61%	4.82%	3.78%	1.05%
840	3.75%	2.78%	2.05%	0.28%
960	2.22%	1.31%	0.77%	0.03%
1080	1.35%	0.25%	0.09%	0.00%
1260	0.76%	0.06%	0.01%	0.00%
1440	0.33%	0.00%	0.00%	
1620	0.09%	0.00%	0.00%	
1800	0.00%	0.00%		
1980	0.00%			

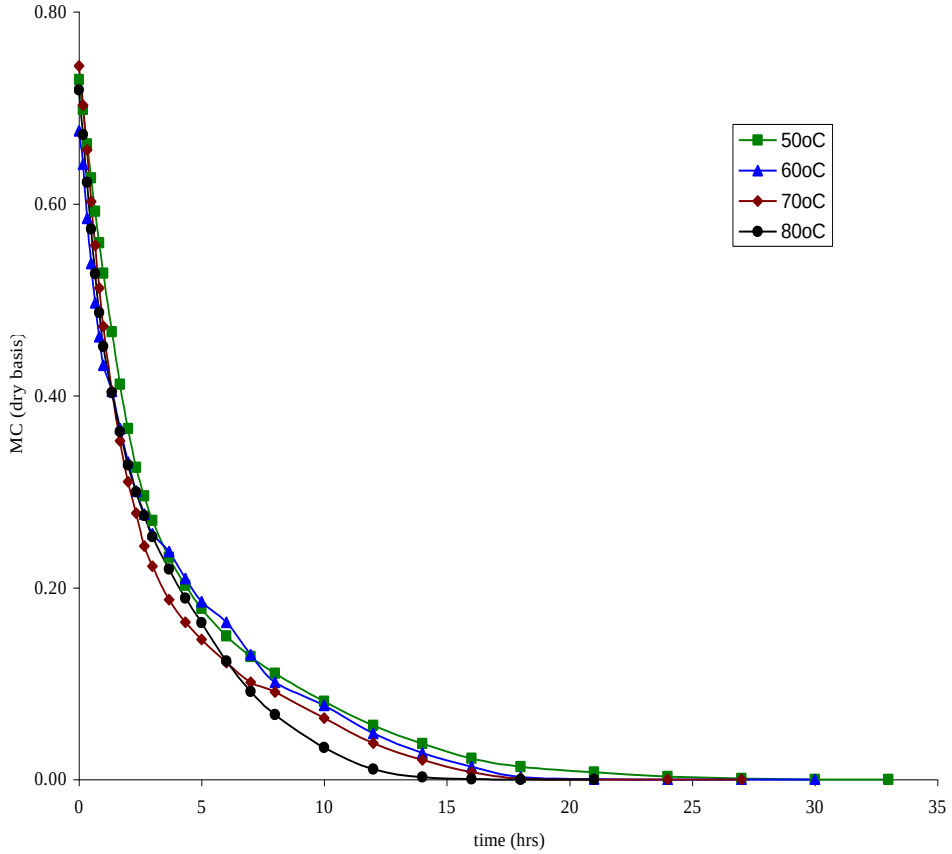


Fig 4.2: Drying curves of dika nuts at 4 temperature levels

3.2.3 Effect of drying temperature and seed state on the nutritional compositionof dikakernels

The results of the proximate and mineral composition at different temperatures and seed states are as shown in Table 4.4. The drying temperature and seed state had a significant ($p > 0.05$) effect on the proximate and mineral composition of the dika kernels. For Crude protein, kernels dried at 50^{o}C before shelling (T12) gave the highest significant value of crude protein while sun dried kernels (T00) gave the least significantvalue. For Crude fibre, kernels dried at 70^{o}C after shelling (T31) gave the highest significant value while kernels dried at 60^{o}C before shelling (T22) gave the lowest significant value for crude fibre.For Ether Extract, kernels dried at 70^{o}C before shelling (T32) gave the highest significant value while kernels dried at 70^{o}C after shelling (T31) gave the lowest significant value.For ash, kernels dried at 50^{o}C after shelling(T11) gave the highest significant value while T12 and T32 gave the least significant value. For moisture content, sun dried kernels(T00) gave the highest significant value while kernels dried at 60^{o}C after shelling(T21) andkernels dried at 70^{o}C after shelling(T31) gave the lowest significant value.For Calcium, kernels dried at 80^{o}C after shelling(T41) gave the highest significant value while kernels dried at 70^{o}C before shelling (T32) gave the lowest significant value.For magnesium, sun dried kernels (T00) gave the highest significant value while kernels dried at 70^{o}C

before shelling(T32) gave the lowest significant value.For potassium, kernels dried at 50^{o}C before shelling(T12)gave the highest significant value while, sun dried kernels (T00) gave the lowest significant value. For phosphorus, kernels dried at 60^{o}C before shelling (T22) gave the highest significant value while kernels dried at 50^{o}C after shelling (T11) and kernels dried at 80^{o}C before shelling (T42) gave the lowest significant value.

Table 4.4 Duncan grouping of theeffect of different drying treatment on the nutritional composition of dika kernels

Composition	Drying Temperature (^{o}C)								
	T00	T11	T12	T21	T22	T31	T32	T41	T42
Crude Protein (%)	8.49 ^{e}	9.76 ^{b}	10.19 ^{a}	8.95 ^{d}	8.91 ^{d}	9.34 ^{c}	9.76 ^{b}	9.34 ^{c}	8.91 ^{d}
Crude Fibre (%)	23.33 ^{h}	23.88 ^{g}	30.33 ^{e}	30.41^{d}	13.14 ^{i}	34.81 ^{a}	27.28 ^{f}	32.07 ^{c}	33.88 ^{b}
Ash (%)	1.75 $^{d e}$	2.52 ^{a}	1.68^{ef}	1.97 ^{c}	1.91 ^{c}	2.16 ^{b}	1.64 ^{f}	1.90 ^{c}	1.77 ^{d}
Ether Extract (%)	58.21 ^{f}	68.48 ^{c}	74.63 ^{b}	65.02	57.63 ^{g}	48.96 ^{h}	75.59 ^{a}	74.75 ^{b}	60.16 $^{d e}$
Moisture (%)	7.00 ^{a}	3.15 ^{e}	4.72 ^{c}	2.81 ^{g}	6.24 ^{b}	2.84 ^{g}	4.80 ^{c}	3.03 ^{f}	3.67 ^{d}
Calcium (mg/g)	0.33 $^{a b}$	0.32^{abc}	0.28 ^{c}	0.34 ^{a}	0.29 $^{b c}$	0.32^{abc}	0.20 ^{d}	0.36 ^{a}	0.23 ^{d}
Potassium (mg/g)	8.13 ^{f}	13.75 ^{c}	25.63 ^{a}	8.13 ^{f}	11.88 ^{d}	13.75 ^{c}	13.75 ^{c}	14.38 ^{b}	9.38 ^{e}
Magnesium (mg/g)	4.46 ^{a}	3.67 ^{d}	3.39 ^{e}	3.44 ^{e}	3.58 ^{d}	3.88 ^{c}	2.94 ^{g}	3.99 ^{b}	3.18 ^{f}
Phosphorus (mg/g)	0.16 ^{c}	0.12 ^{f}	0.15 ^{d}	0.13 ^{e}	0.20 ^{a}	0.16 ^{c}	0.16 ^{c}	0.17 ^{b}	0.12 ^{f}

a b c d e f g h i - means with the same superscript are not significantly different at p > 0.05

T00 = Sun dried Dika kernels;

T11 = Dried at 50^{o}C after shelling; T12 = Dried at 50^{o}C before shelling;

T21 = Dried at 60^{o}C after shelling; T22 = Dried at 60^{o}C before shelling;

T31 = Dried at 70^{o}C after shelling; T32 = Dried at 70^{o}C before shelling;

T41 = Dried at 80^{o}C after shelling; T42 = Dried at 80^{o}C before shelling

3.2.4 Optimum temperature for artificial drying

From Table 4.4, using the mineral composition as a basis for comparison, kernels dried at 80^{o}C after shelling (T41) yielded the significantly highest value for calcium and also the second

highest value for potassium, magnesium and phosphorus, thereby, giving the best treatment for the mineralas compared to the other treatments.

4.0CONCLUSION

The following conclusion can be drawn from the results of the experiment:

1. Drying rate increased with increased temperature for both nuts and kernels.
2. Drying was faster when drying kernels than when drying nuts.
3. The nutritive quality of sun dried kernels was less than that of most of the artificially dried kernels.
4. Using mineral composition as the basis, kernels dried at 80^{o}C after shelling gave the mineral content.

REFERENCES

Akubor, P. I. (1996). The sustainability of African bush mango juice for wine production.Plant Foods for Human Nutrition. Dordrecht 49(3) 213-219.

ASAE (1997).ASAE Standard S412.2.Moisture measurement of oil seeds.

Doymaz I. (2005) Drying behaviour of green beans.Journal of Food Engineering. 69. 161–165.

Giner S. A. and Gely M. C. (2005) Water–corn equilibrium: temperature dependency of the G.A.B. model parameters and calculation of the heat of sorption.Drying Technology 18: 1449–1464.

Leakey, R. R. B. & J. A. Maghembe (undated). "Domestication of High Value Trees for Agroforestry: An Alternative to Slash and Burn Agriculture." ICRAF Position Paper 1.

Mwithiga G and Olwal J. O. (2004) The drying kinetics of kale (Brassica oleracea) in a convective hot air dryer. Journal of Food Engineering.71: 373-378.

Ogunyemi O (2007) Proximate analysis of seeds. Handbook, Department of animal science.OAU Ile-Ife.

Sacilik K. and Unal G. (2005), Dehydration characteristics of Kastamonu Garlic slices.Journal of Biosystem Engineering.92: 207 – 215.

SOME ENGINEERING PROPERTIES OF PROSOPIS AFRICANA (OKPEYE) SEEDS

ASOIRO, F.U., NWOKE,O.A., and EZENNE,G.I.

Department of Agricultural and Bioresources Engineering, University of Nigeria, Nsukka.felixasoiro@yahoo.com

ABSTRACT

An investigation was carried out on some engineering properties of prosopisafricana seeds(Okpeye) which are needed for machine/ system design construction and fabrication. The engineering properties investigated were both the physical and mechanical properties. The physical properties investigated include seed length, width, thickness, geometric mean diameter, arithmetic mean diameter, sphericity, aspect ratio, surface area and specific surface area. Others are solid volume, bulk volume,solid mass, solid density, bulk density, density ratio, porosity, 1000 unit mass, coefficient of static friction, moisture content and angle of repose. The mechanical properties studied were bioyield force, rupture force, compressive strength, deformation at rupture and total strain energy. The mean length , width and thickness of the seed were found to be 0.9649cm, 0.6236cm, and 0.4186cm respectively. The geometric mean diameter, equivalent mean diameter, arithmetic mean diameter sphericity and aspect ratio were found to be 0.6300cm, 0.7728cm, 0.6690cm, 0,6557cm and 0.6500cm respectively while the surface area, specific surface area, specific surface area, solid volume and bulk volume were 1.9764cm^2, 10.9173cm^2/cm^3, 0.1852cm^3 and 50cm^3 respectively. The coefficient of static friction obtained on three surfaces namely asbestos, aluminium, and plywood were 0.3228, 0.3092, and 0.3331 respectively. The solid mass, 1000 unit mass, solid density, bulk density, density ratio and porosity were 0.1705g, 16.1488g, 0.9374g/cm^3, 0.8375g/cm^3, 120.0276 and 13.1313% respectively. By emptying method, the angle of repose was found to be 22.5^o while moisture content wet and dry basis were 5.9988% and 5.6257% respectively. In the mechanical aspect, the average the average bio-yield force needed to crack the seed across the length width and thickness were 162.54N, 161.28N, and 116.55N respectively while the average force needed to rupture the seed across the same dimension were 175.14N, 174.14N and 129.15N respectively. The mean compressive strength applied on the seed length, width and thickness were 0.8848N/mm^2, 0.8848N/mm^2 and 0.6525N/mm^2 respectively. The deformation at rupture for the three dimentions were 2.6mm for length, 2.276mm for width and 2.476 mm for thickness. The total strain energy expended for the length, width and thickness were 425.4075J, 396.2386J and 315.1071J respectively.

1.0 Introduction

Prosopis is a genus of flowering plants in the pea family, fabaceae. It contains around 45 species of spinytrees and shrubs found in subtropical and tropical regions of the Americas, Africa, Western Asia, and South Asia. They often thrive in aridsoil and are resistant to drought, on occasion developing extremely deep root systems. Their wood is usually hard, dense and durable. Their fruits are pods and may contain large amounts of sugar. The generic name means "burdock" in late Latin and originated in the Greek language. It reaches 4-20min height; has an open crown and slightly rounded buttresses; bark is very dark, scaly, slash, orange tored-brown with white streaks.The English name of Prosopisafricana is a matter of controversy as some people call it

iron tree while others identify iron tree as a different tree but it ispopularly known all over the world as mesquite. Due to the large numbers of species, however, most research reports use the scientific name to identify the particular specy which is under study. It was once said that Prosopis Africana is the only tropical Africana Prosopisspecies, occurring from Senegal to Ethiopia in the zone between the Sahel and savannah forests of Africa especially in Nigeria and Senegal. Due toextensive overexploitation, it has disappeared from extensive parts of the Southern Sahel and the adjacentSudan savannahs(Von May dell, 1986;Vogt, 1995). The trees of ProsopisAfricana are common in the Middle belt and Northern parts ofNigeria. The local names In Nigeria are Ayan (Yoruba), Ubwa(Igbo), Kiriya (Hausa),Kohi (Fula) and Okpeye (Idoma/Tiv). Though this fruit is edible, it is often notdelibrately cultivated but grows wild which makes it an endangered specy(Ola-Adams and Onyeachusim, 1993).

Prosopis Africana is a perennial leguminous tree of the subfamily of mimosoidae(Keay et al., 1964). In Nigeria, the trees are found in latitude 7^{o}N and 10^{o}N(Agboola, 1995) and the seeds are very important to the Idomas, Tives, Igbos, Igalas and Ebiras who use them to prepare delicacious, spicious food condiment known as Okpeye which is consumed by more than 10 million people(Onyeyiola, 1999). The condiment which is prepared by the fermentation of the seed is very rich in protein, ash, fibre, fatty acid and a little quantity of vitamins(Sanni et al., 1993a,b;Barminas et al.,1998).The pod pulp of Prosopisafricanacontains an energy value of 1168 J, 9.6% protein, 3% fat and 53% carbohydrate. It contains 160 mg of calcium and 70mg of iron per 100 g of fresh weight (FAO, 2003).Prosopis Africana trees have multiple applications. The trees can be used as valuable sources of fuel by rural communities of developing countries for cooking, heating and drying of other fishes and other crops. It can also be a source of timber for the construction of furniture, hoes, pestles, bows and mortars as well as for fencing. It could also be used as shade from the sun and shelter from wind, food for people and folder for animals. In many instances it could be used for erosion control, soil stabilization and soil nutrient (Diagne, 1992; Alabi, 1993). When dried the roots could be used as chewing stick by the Yorubas in Nigeria in other to promote dental health and improve oral hygiene in areas where tooth brush is uncommon.Almost all parts of the plants has medicinal uses. In Mali the leaves are used to treat headache, tooth ache as well as other head ailment. The bark and leaves are combined to treat rheumatism. The bark, twigs and roots are used to treat and relieve bronchitis. Fishermen use the pounded dried fruit as fish poison. The bark and root can be used as tannin or dyestuff and the pod ashes are a source of potassium for making soap used to treat skin disease, fevers and as eyewashes. They contain 14–16% tannin and a colouringmatter that gives a reddish tint to leatherKerry (2008) reported that the plants have also been incorporated in the treatment of dermatitis, tooth decay, dysentery, malaria and stomachcramps. In Ghana, boiled roots serve as poultice for sore throat; root decoction for toothache and the bark are used for the treatment and dressing or lotion for wounds or cuts (WAC,2008).

Despite the huge economic and agricultural potential of this seed, very little information is available in literature on the physical properties of the seed and none on the mechanical properties.Yetthese are all relevant parameters in the design of machines, systems, controls and equipment for the mechanization ofprocessing, storage, harvesting and transportation of these seeds. All that areavalaible in literature are Phytochemical Composition and Antimicrobial Activity of*Prosopisafricana*Against Some Selected Oral Pathogens **(**Kolapo et al.,2009),Some Nutritional and Functional Studies of Prosopis Africana (Aremu et al., 2006), Quantitative variations in the growth of progeny seedlings of Prosopis Africana in Nigeria (Akinnagbe and

Oni,2007),The production of 'Kpaye' – a fermented condiment from Prosopis Africana Seeds (Omafuvbea et al., 1999)

Many researchers have determined the physicalproperties of other seeds and grains, viz., pigeon pea(Shepherd &Bhardwaj, 1986), gram (Dutta et al., 1988),soyabean (Sreenarayanan et al., 1988; Deshpande et al.,1993), oil bean seed (Oje&Ugbor, 1991), neem nuts(Visvanathan et al., 1996), karingda seed (Suthar& Das,1996), cumin seed (Singh &Goswami, 1996), lentil seeds(Carman, 1996), sunflower seeds (Gupta & Das, 1997),coffee (Chandrasekar&Viswanathan, 1999), greengram (Nimkar&Chattopadhyaya, 2001), chick peaseeds (Konak et al., 2002) quinoa seeds (Vilche et al.,

2003), hemp seed (Sacilik et al., 2003), faba bean(Haciseferogullaria et al., 2003), African yam beans(Asoiro and Ani, 2011),rapeseed (Calisiret al., 2005) and Jatropha (Shkelqim and Joachim, 2010) but no much yet on the physical and mechanical properties of this seed. The size and shape are, for instance, important in their electrostatic separation from undesirable materials and in the development of sizing and grading machinery (Mohsenin, 1986). The shape of the material is important for an analytical prediction of its drying behavior (Esref andHalil,2007). Bulk density, true density and porosity (the ratio of intergranular space to the total space occupied by the grain) can be useful in sizing grain hoppers and storage facilities; they can affect the rate of heat and mass transfer of moisture during aeration and drying processes. Seed bed with low porosity will have greater resistance to water vapor escape during the drying process, which may lead to higher power to drive the aeration fans. Grain or seed densities have been of interest in breakage susceptibility and hardness studies. The static coefficient of friction is used to determine the angle at which chutes must be positioned in order to achieve consistent flow of materials through the chute. Such information is useful in sizing motor requirements for seed transportation and handling (Ghasemi et al.,2007). The design of storage and handling systems for seeds requires data on bulk and handling properties, friction coefficients on commonly used bin wall materials (galvanized steel, plywood and concrete) and emptying and filling angles of repose (Parde et al.,3003). Theories used to predict the pressures and loads on storage structures (Lvin, 1970). require bulk density, angle of repose and frictioncoefficients against bin wall materials. Also the design of grain hoppers for processing machinery requires data on bulk density and angle of repose. An example of the use of various bulk and handling properties of seeds in the design of storage structures is given by Singh and Moysey (1985). The angle of repose determines the maximum angle of a pile of seeds with the horizontal plane. It is important in the filling of a flat storage facility when seeds are not piled at a uniform bed depth but rather is peaked (Mohsenin, 1986). Hence, current study was conducted on investigate some physical and mechanical properties of prosopis Africana seed in other to come up with a valuable design data for its mechanization and processing.

2.0 MATERIALS AND METHODS

2.1 Sample

The matured-dried seed pod of ProsopisAfricana(Figure 2.2) were sourced from some local farmers in Alome village, Kogi state of Nigeria. The seeds (Figure 2.1) were removed from the pod and cleaned manually by hand to remove all foreign matter such as dust, dirt, pieces of stones, chaff as well as broken and imature seeds. Measurement of the physical and mechanical

properties werelater carried out in the Food and Bioprocess Laboratory and Civil Engineering Laboratory respectively both in the University of Nigeria, Nsukka.



Figure 2.1: Mature Seeds of Prosopis Africana with a VernierCalliper for Measurement



Figure 2.2: Mature Pods of Prosopis Africana

2.2 Physical Properties

2.2.1 Determination of moisture content

The moisture content of the seed was determined using the ASAE (1983) recommended

method for edible beans. This involves the oven dryingof seed samples at 103^{o}C for 72 hours. The samples wereallowed to cool in a dessicator after which it was weighed and recorded using an electronic balance (Yamato, model HB 3000, Japan) reading to 0.01g in order to determine the moisture loss.Twenty (20) samples were randomly collected from 50kg of Prosopisafricana. Each of the samples usedweigh 20g. The measurement on each sample were replicated three times and the average moisture content taken. The moisture content of the seed in % (wetand dry basis) was calculated with the following formula:

$$MC_{wb} = 100\frac{M_i - M_f}{M_i} \quad (1)$$

$$MC_{db} = 100\frac{M_i - M_f}{M_f} \quad (2)$$

Where MC_{wb} and MC_{db} are moisture content wet basis and moisture content dry basis of seed (%) respectively, M_i and M_f are initial mass and final mass of seed(g or kg) respectively.

2.2.2 Determination of solid density, bulk density, density ratio and porosity

The solid density is the ratio of mass sample of the seed to its solid volume. It was determined by the waterdisplacement method (Mohsenin, 1986).

Bulk density is the ratio of the mass sample of the seed to its total volume. It wasdetermined by filling a predefined container from aconstant height, striking the top level and then weighingthe constants (Deshpande et al., 1993;Gupta and Das, 1997; Konak et al., 2002; Paksoy and Aydin, 2004; and Asoiro and Ani, 2011).

The density ratio Dr is the ratio of solid density to bulk density expressed as a percentage as follows:

$$D_r = \frac{\ell_s}{\ell_b} \times 100 \quad (3)$$

The porosity is the ratio of free space between seedto total of bulk seed. It is expressed in percentage. This was determined as:

$$\varepsilon = \frac{\ell_s - \ell_b}{\ell_s} \times 100 \quad (4)$$

Where ε is porosity in percentage, ℓ_b and ℓ_s are bulk density and solid density (g/cm^3 or kg/m^3) respectively.

2.2.3 Determination of size and shape

A Vernier caliper (Mitutoyo, model Absolute Digimatic, Japan) reading to 0.01 mm was used to measured the lenght, width and thickness of Prosopisafricana seed. This was done using 100 randomly selected seeds from a 50kg weight as demonstrated by Mohsenin (1980). The geometric mean diameter, D_g , equivalent mean diameter, D_p and arithmetic mean diameter, D_a , in cm was calculated by usingeq(5), eq(6) and eq(7) respectively as presented in the expressions:

$$D_g = (LWT)^{\frac{1}{3}} \quad (5)$$

$$D_p = \left[L \frac{(L+T)^2}{4} \right]^{\frac{1}{3}} \quad (6)$$

$$D_a = \frac{(L+W+T)}{3} \quad (7)$$

The sphericity (S_p) defined as the ratio of the surface area of the sphere having the same volume as that of seed to the surface area of seed. It was determined using the expression in equ (8) (Mohsenin, 1986):

$$S_p = \frac{(LWT)^{\frac{1}{3}}}{L} \text{ or } \frac{D_g}{L} \quad (8)$$

The aspect ratio (Ra) was calculated using equ. (9) as given by Omobuwajo*et al*. (1999)

$$R_a = \frac{W}{L} \quad (9)$$

2.2.4 Determination of surface area and specific surface area

Surface area S (mm^2) and specific surface area Ss (cm^2 /cm^3)were estimated by the relationship given by McCabe et al. (1986) which is given in equ (10) as:

$$S = \prod {D_g}^2 \text{ or } \prod (LWT)^{\frac{1}{3}} \quad (10)$$

Where S is surface area (cm^2) and D_g is geometric mean diameter (cm).

The specific surface area is given by the expression in equ. (11)

$$S_s = \frac{S}{V} \text{or} \frac{S\ell_b}{M_s} \quad (11)$$

Where S_s is specific surface area(cm^2 /cm^3), S is the surface area (cm^2), M_s is mass of unit seed(grams) and ℓ_b is the bulk density of seeds(g/cm^3)

2.2.5 Determination of solid volume and bulk volume

The volume of the individual and bulk seeds were determined by water displacement method equs. (12) and (13) are given for their calculations.

$$V_s = \frac{M_w}{\ell_t} \tag{12}$$

Where V_s is solid volume(cm^3), M_w is the mass of individual seed in water (grams) and ℓ_t is density of water($1.0g/cm^3$).

$$V_b = \frac{M_{wb}}{\ell_t} \tag{13}$$

Where V_b is bulk volume (cm^3), M_{wb} is the mass of bulk seed in water (grams) and ℓ_t is the density of water ($1.0g/cm^3$)

2.2.6 Determination of coefficient of stataic friction on various surfaces

The coefficient of static friction of the seeds was determined against three structural

materials: asbestos, aluminum and plywood. A wooden box measuring 450 mm X 300 mm X 120 mm was constructed without a base (Olajide et al., 2000) and placed on an adjustable tilting plate, facing the test surface. There were two pieces of plastic between the box and the plate placed under the sides of the walls of the box oppositely to raise the box up and not to touch the plate surface. Then the box was filled with the sample, the two pieces of plastic removed which made the box to remain above the plate, but the sample touched the plate. The inclination of the plate was increased gradually by a screw device until the box just starts to slide down. The angle of tilt ϕ in degree was read from a graduated scale. This was done in five replicates and the coefficient of static friction, μ calculated from the expression (Shepherd and Bhardwaj, 1986; Joshi et al., 1993; and Pliestic et al., 2006) in equ. (14) below:

$$\mu = \text{Tan}\,\phi \tag{14}$$

Where μ is the coefficient of friction.

2.2.7 Determination of angle of repose

The angle of repose indicates the cohesion among the individual units of the seed. The higher the cohesion, higher is the angle of repose.The dynamic angle of repose is the angle with the horizontal at which the material will stand when piled. The angle of repose is determined using a hollow cylinder and then trigonometry rules (*Heidarbeigi* et al. 2008). The angle of repose of Prosopisafricana seed was measured by the emptying method put forward by Shkelqim and Joachim, 2010. Later was calculated using the expression in equ. (15)

$$\theta = Tan^{-1}\left(\frac{2H}{D}\right) \tag{15}$$

Where θ isangle of repose (^{o}), H is height of the pile (cm) and D is diameter of the pile (cm).

2.2.8 Determination of solid mass and thousand unit mass of seeds

1000-units of the seed were randomly selected from a mass of 50kg, weighed and recorded. This was replicated five times and the average taken.

2.3 Mechanical Properties

2.3.1 Determination of bio-yield force, rupture force, compressive strength, deformation at rupture and energy

Mechanical properties such as bioyield force, rupture force, compressive strength, deformation at rupture and total energy of Prosopis Africana seed were evaluated using 15 samples of the seed. Five samples of the seed were tested for each of the lenght (a), width (b) and thickness (c) loading direction and replicated. This was done by means of aUK- made Universal Testing Machine (Monsanto Tensometer A220-9), shown in Figure 2.The machine was equipped with a load cell of 500 N at a compressive rate of 25 mm/min. Rupture force and deformation of samples were expressed in terms of the peak of force-deformation curve. Energy for rupture, E_R (Nmm) is the energy needed to rupture the sample, which could be determined from the area under the curve between the initial point and the rupture point. The area was measured by using a polarplanimeter with accuracy of ±0.2% (model: OTT-Kompensations-Polarplanimeter). Compressive strength was calculated as the rupture force divided by the deformation. The rupture force, F_R (N) is the minimum force required to break the sample. Deformation at rupture point, R_{DR} (mm) is the deformation at loading direction

Compressive strength, H (N/mm) is the ratio of rupture force and deformationat rupture point. It was calculated using equation 16:

$$H = \frac{F_R}{R_{DR}} \qquad (16)$$

3.0 RESULTS AND DISCUSSION

3.1 Physical Properties

Table 1 shows the summary results of the physical and mechanical properties of prosopisafricana. The discussion on the results is are as follows:

Moisture content: The moisture content value dry basis vary from 4.8715% to 7.8662% with mean value of 5.9988 and a standard deviation of ±0.8040. For wet basis, the moisture content mean was slightly lower than that of dry basis by 6.63%. The mean moisture content, wet basis is 5.6257% with a minimum and maximum value of 4.6452% and 7.0853% respectively.

Solid density, bulk density, density ratio and porosity: The mean solid density and bulk density are 0.93375g/cm^3 and 0.8375g/cm^{3}respectively. The solid density is a slightly more than the bulk density by a value of 11.93%. From the results, the seeds are less dense than water. This makes it possible to separate them from materials that are more dense in water. The density ratio is very high with a mean value of 120.0276 and a standard deviation of ±21.7929. The density ratio range from a minimum value of 65.3455 to a maximum value of 145.94.Prosopis Africana seeds have less pore spaces. The porosity value ranges from -51.03327% to 31.4787% with a mean value of 13.1313%. This value shows how easily a stream of heated air for drying will pass through a pack of material. This will affect the rate of drying of the material. This very important

property is required in air and heat flow in agricultural materials. Seeds with low porosity has less pore spaces and hence will dry very slowly. During aeration of this seeds, high power fans and motor is needed to pass cold air through the pore spaces. Natural aeration will be very difficult and an unlikely choice.

Size and shape: The mean seed length, width and thickness are 0.9649cm, 0.6236 cm and 0.4186 cm respectively. The mean for the geometric mean diameter, equivalent mean diameter, and arithmetic mean diameter are 0.6300cm, 0.7728cm and 0.6690cm respectively while the aspect ratio range from 0.4262 to 0.8333 with a mean value of 0.6500. The shape of the seed is almost a sphere with ranges between 0.4963 to 0.7469, and a mean value of 0.6557 ± 0.0432. This shows that this seed will tend to roll when it is on a particular orientation. These properties are always considered when designing hoppers and dehulling equipment for seeds and grains.

Surface area and specific surface area: The surface area of prosopisafricana seed is very small from 1.7250cm^2 to 2.3417cm^2 with a mean value of 1.9794cm^2 ± 0.1136. The surface area of a biomaterial affects the velocity of air stream that can be used in other to separate the material from an unwanted materials in pneumatic separator or to convey seed in pneumatic conveying. The mean specific surface area is also very small (10.9173cm^2/cm^3). This implies that the mass or energy transfer rate through the surface of the material will be small.

Solid volume and bulk volume: The solid volume of the seed range from 0.1305 cm^3 to 0.2567cm^3 with a mean value of 0.1853cm^3. The bulk volume is 50cm^3.

Coefficient of static friction on various surfaces: Plywood, because of its rough surface has the highest coefficient of static friction (0.3331) followed by Asbestos (0.3228) and Alumminum(0.3092). Surface roughness, as shown from the results, affects the coefficient of static friction. The more the roughness of these material surfaces the higher the coefficient of static friction. These values determine how a pack of seeds or grain will flow in these systems (surfaces). This is a design parameter needed in the design of agricultural machine hoppers and other conveying equipment

Angle of repose: Using the emptying method, the angle of repose of prosopisafricana is 22.5^o. The values range from 21.58^o and 22.72^0 with a standard deviation of ± 0.37. This property help to determine the minimum slope of flow in self emptying bin and minimum slop flow in a hopper.

Solid mass and thousand unit mass of seeds: The seed has a mean solid mass of 0.1705g which ranges from 0.0612g to 0.2273g. The mean value of the 1000-unit mass of the seed is 16.1488g with ranges of values between 15.6344g and 16.14930g.

3.2 Mechanical Properties

Bio-yield force, rupture force, compressive strength, deformation at rupture and total strain energy: Prosopisafricana seed length has the highest bio-yield force (162.54N) when compared with the width (161.28N) and Thickness (116.55N). The rupture force for the seed isthe same for both the seed length and width with a value of 175.14N while the value for the thickness is 129.15N and ranges from 97.65N to 185N. This implies that the seed is stronger across the length and width but weaker across the thickness.It will require a less force to crack the seed across the thickness than across the length and width. The mean compressive strength for the

seed across the length is 0.8848N/mm^2 with ranges of 0.7161N/mm^2 to 0.9548N/mm^2. The value across the width is the same with that across the length with ranges of 0.6843 N/mm^2 and 1.0344 N/mm^2.

The compressive strength of the seed across the thickness ranges between 0.4933N/mm^2 to 0.9389N/mm^2 with a mean value of 0.6525N/mm^2. The deformation at rupture is 2.6mm for length, 2.276mm for width and 2.476mm for thickness with ranges of the length, width, and thickness as 1.75mm to 3.75mm, 1.75mm to 2.75mm and 1.75mm to 3.25mm respectively. The total strain energy for breaking the seed is 425.4075J across the length, 396.2386J across the width and 315.1071 across the thickness with ranges of 248.0625J to 639.45J, 292.1625J to 487.305J and 244.125J to 491.4J, 292.1625 to 487.305J and 244.125J to 491.4J for the length, width and thickness respectively.

2.0 CONCLUSIONS

The following conclusions are drawn:

1. Dimensions for prosopis Africana seed(Okpeye) ranges from 0.4186cm to 0.9649cm.
2. The sphericity is 0.6557. This indicates that the material is close to a sphere. This material will tend to roll when placed on a particular orientation.
3. The surface area, specific surface area, solid volume, bulk volume, solid mass, solid density, bulk density and 1000- unit mass were determined as 1.9794cm^2, 10.9173cm^2/cm^3, 0.1852cm^3, 50cm^3, 0.1705g, 0.9374g/cm^3, 0.8375g/cm^3 and 16.1488g respectively.
4. The bulk and solid density showed that the seed will float in water. This makes it possible to separate from materials that are more dense than water such as sand and stone.
5. The coefficient of static friction for the three different material surfaces studied showed that Plywood offered the most resistance to flow(0.3331), followed by Asbestos (0.3228) and Aluminium (0.3092).these values are needed in the design of agricultural machine hopper and other conveying equipment.
6. The porosity of the seed is small(13.1313%). Due to this, drying would be slow. High powered fan is needed to pass cold air through the pore spaces during aeration. Natural aeration would be difficult and an unlikely choice.
7. The angle of repose, moisture content wet and dry basis were 22.5^o, 5.6257% and 5.9988% respectively.
8. The force needed to crack the seed were found to be highest across the length(162.54N) and least across the thickness(116.55N) while the force needed to rupture the seed were found to be highest across both the length and width(175.14N) and least across the thickness(129.14N)
9. The compressive strength was maximum across both the length and width(0.8848N/mm^2) and minimum across the thickness(0.6525N/mm^2).
10. The total strain energy was maximum across the length(425.4075J) and minimum across the thickness while the deformation at rupture was maximum across the length(2.6mm) but minimum across the width(2.276mm)

REFERENCES

Asoiro F U and AniA O. 2011. Determination of some physical properties of African yam beans, Pacific Journal of Science and Technology. 12(1):374-380.

Barminas J T; Marina H M; Ali J. 1998. Nutrient content of Prosopisafricana seeds. Plant Foods for Human Nutrition, 52(4), 325–328.

Calisir S; Marakoglu T; Ogut H; Ozturk O .2005.Physical properties of rapeseed (Brassica napusoleifera L.). Journal of Food Engineering, 69, 61–66

Carman K 1996. Some physical properties of lentil seeds. Journal of Agricultural Engineering Research, 63, 87–92.

Chandrasekar V; Viswanathan R .1999.Physical and thermal properties of coffee. Journal of Agricultural Engineering Research, 73(2), 227–234

Deshpande S D; Bal S; Ojha T P .1993. Physical properties of soybean. Journal of Agricultural Engineering Research, 56(2), 89–98

Deshpande, S.O., S. Bal and T.P. Ojha, 1993. Physical properties of soybean. J. Agric. Eng. Res, 56: 89-98.

Dutta S K; Nema V K; Bhardwaj R K .1988.Physical properties of gram. Journal of Agricultural Engineering Research, 39(4), 259–268

Esref, I. and U. Halil, 2007. Moisture-dependent physical properties of white speckled red kidney bean grains. J. Food. Eng., 82: 209-216.

FAO.2003. Non-Wood Forest products and Nutrition. Food and Agricultural Organisation of the United Nations, Food and Nutrition Division Publication

GhasemiVarnamkhasti, M., H. Mobli, A. Jafari, S. Rafiee, M. HeidarySoltanabadiand K. Kheiralipour, 2007. Some Engineering Properties of Paddy (var. Sazandegi). Int. J. Agric and Biol., 5: 763-766.

Gupta R K; Das S K 1997.Physical properties of sunflower seeds. Journal of Agricultural Engineering Research, 66, 1–8.

Gupta, R.K. and S.K. Das, 1997.Physical propertiesof sunflower seeds. J. Agric.Eng. Res., 66: 1-8.

Haciseferogullaria H; Gezer I B; Bahtiyarca Y C; Menges H O.2003. Determination of some chemical and physical properties of sakizfaba bean (Viciafaba L. Var. major). Journal of Food Engineering, 60, 475–479

Heidarbeigi K, H. Ahmadi, K. Kheiralipour and A. Tabatabaeefar.*2008.*Some Physical and Mechanical Properties of Iranian Wild Pistachio (*Pistachio mutica L.*). American-Eurasian J. Agric. & Environ. Sci., 3 (4): 521-525,

Janssen, H.A., 1895. Versucheubergetreidedruck in silozellen. Z. vereinesDeutscherIngenieure, 39: 1045-1049.

Joshi, D.C., S.K. Das, and R.K. Mukherjee. 1993. "Physical Properties of Pumpkin Seeds". *Journalof Agricultural Engineering Research*.54:219– 229.

Journal of Food Engineering, 60, 475–479

Kerry, B., 2008. Phytotherapy for Periodontal disease and improved oral hygiene (Phytotherapy Review and Commentary) http://www.mediherb.com

Konak M; Arman K C; Aydin C (2002).Physical Properties of Chick Pea Seeds.Biosystems Engineering, 82(1), 73–78

Konak, M., K. Carman and Aydin, C, 2002.Physicalproperties of chick pea seeds.Bio-systems. Eng., 82: 73-78.

Lvin, J.B., 1970. Analytical evaluation of pressures of granular materials on silo walls. Powder Tech, 4: 280-285.

Mohsenin, N.N., 1986. Physical Properties of Plant and Animal Materials, seconded. Gordon and Breach Science Publishers, New York.

Nimkar P M; Chattopadhyaya P K .2001.Some physical properties of green gram. Journal of Agricultural Engineering Research, 80(2), 183–189

Oje K and Ugbor E C .1991. Some physical properties of oil bean seed. Journal of Agricultural Engineering Research, 50(4), 305–313

Olajide, J.O, B.I.O. Adepomowaye, and E.Y Otunola. 2000. "Some Physical Properties of Shea Kernel". *Journal of Agric, Engr. Res.* 76:419-421.

Omobuwajo.O.T., A.E. Akande and A.L. Sann, 1999.Selected physical, mechanical and aerodynamic properties African Breadfruit (Treculia Africana) seeds. J. Food. Eng., 40: 241-244.

Oyeyiola G P. 1999. Fermentation of Ogirihttp://www. Biologie.uni-hambood.de/b-online/ibi99/ibc/abstracts5028. html. HTML-Version made July 1999 by Kurt Stuber.

Paksoy, M. and C. Aydin, 2004.Some physicalproperties of edible squash (*Cucurbitapepo*L.) seeds. J. Food Eng., 65: 225-231.

Parde.S.R., A. Johal, D.S. Jayas and N.D.G. White, 2003.Physical properties of buckwheat cultivars.Canadian Bio-systems.Eng, Technical Note.

Pliestic, S., N. Dobricevic, D. Filipovic, and Z. Gospodaric. 2006. "Physical Properties of Filbert Nut and Kernel". *Journal of BiosystemsEngineering*. 93(2):173-178.

Sacilik K; Ozturk R; Keskin R (2003).Some physical properties of hemp seed.Biosystems Engineering, 86(2), 191–198

Shepherd H; Bhardwaj R K .1986. Moisture-dependent physical properties of pigeon pea. Journal of Agricultural Engineering Research, 35(4), 227–234

Shkelqim K and Joachim M. 2010. Determination of physical, mechanical and chemical properties of seeds and kernels of Jatrophacurcas L. Industrial Crops and Products 32 (2010) 129–138

Singh K K; Goswami T K .1996.Physical properties of cumin seed. Journal of Agricultural Engineering Research, 64, 93–98

Singh, D. and E.B. Moysey, 1985.Grain bin wall pressures.Theoretical and experimental.Canadian Agric. Eng., 27: 43-48.

Sreenarayanan V V; Viswanathan R; Subramanian V .1988.Physical and thermal properties of soybean. Journal of Agricultural Engineering, 25(4), 76–82

Suthar S H; Das S K (1996).Some physical properties of karingda [Citrulluslanatus (Thumb) Mansf] seeds. Journal of Agricultural Engineering Research, 65, 15–22

Vilche C; Gely M; Santalla E 2003.Physical properties of quinoa seeds.Biosystems Engineering, 86(1), 59–65

Visvanathan R; Palanisamy P T; Gothandapani L; Sreenarayanan V V (1996).Physical properties of neem nut. Journal of Agricultural Engineering Research, 63, 19–26

Vogt, K. A.1995. Field guide to the identification, propagation and uses of common trees and shrubs of dry land Sudan.SOS, SAHEL International (1995).

Von May dell, H. J.1986. Trees and Shrubs of the Sahel – their characteristics and uses. GTZ6MBH, Esuborn (1986)

World Agroforestry Centre(WAC). 2008. Agroforestree Database. http://www.worldagroforestrycentre.org/ sites/treedbs/aft/speciesPrinterFriendly.asp?Id=1346. Accessed on November 27, 2003

Table 1.0 Summary of the physical and mechanical properties of prosopisafricana (Okpeye)

PHYSICAL PROPERTIES					
Property	**N**	**Mean**	**Standard Deviation(SD)**	**Maximum Value**	**Minimum Value**
Length, L(cm)	100	0.9649	0.0848	1.25	0.76
Width,W(cm)	100	0.6236	0.0525	0.76	0.52
Thickness, T(cm)	100	0.4186	0.0413	0.53	0.3
Geometric Mean Diameter,Dg(cm)	100	0.6300	0.0361	0.7453	0.5490
Equivalent Mean Diameter, Dp(cm)	100	0.7728	0.0567	0.9704	0.642
Arithmetic Mean Diameter, Da(cm)	100	0.6690	0.0394	0.81	0.5767
Sphericity, Sp	100	0.6557	0.0432	0.7469	0.4963
Aspect Ratio, Ra	100	0.6500	0.0676	0.8333	0.4262
Surface Area, S(cm^2)	100	1.9794	0.1135	2.3417	1.7250
Specific Surface Area, Ss(cm^2/cm^3)	100	10.9173	1.7692	17.0531	7.4919
Solid Volume, Vs(cm^3)	100	0.1852	0.0272	0.2567	0.1305
Bulk Volume, V_b (cm^3)	20	50	0.0000	50	50
Solid Mass, M_s (g)	100	0.1705	0.0322	0.2273	0.0612
Solid Density, ℓ_s (g/cm^3)	100	0.9374	0.2135	1.5939	0.3031
Bulk Density, ℓ_b (g/cm^3)	20	0.8375	0.0355	0.9051	0.8020
Density Ratio, D_r	20	120.0276	21.7929	145.94	65.3455
Porosity, ε	20	13.1313	21.2134	31.4787	-53.0327
1000 Unit Mass (g)	5	16.1488	0.3538	16.4930	15.6344
		Coefficient of static friction on various surfaces			
Asbestos	5	0.3228	0.0318	0.352	0.2772
Aluminium	5	0.3092	0.00904	0.3162	0.2944
Plywood	5	0.3331	0.00858	0.343	0.3207
		Angle of repose			
Emptying Method (^{o})	5	22.5	0.37	22.72	21.58
Moisture content Dry Basis,db(%)	20	5.9988	0.8040	7.8620	4.8715

PHYSICAL PROPERTIES					
Property	**N**	**Mean**	**Standard Deviation(SD)**	**Maximum Value**	**Minimum Value**
Wet Basis, wb(%)	20	5.6257	0.6483	7.0853	4.6452
MECHANICAL PROPERTIES					
		Seed Length, L			
Bio-yield Force (N)	5	162.54	21.6641	182.7	126
Rupture Force (N)	5	175.14	18.9786	189	141.75
Compressive Strenght(N/mm^2)	5	0.8848	0.0959	0.9548	0.7161
Deformation at Rupture (mm)	5	2.6	0.9454	3.75	1.75
Total Strain Energy (J)	5	425.4075	149.8677	639.45	248.0625
		Seed Width, W			
Bio-yield Force (N)	5	161.28	28.3850	185.85	116.55
Rupture Force (N)	5	175.14	26.5050	204.75	135.45
Compressive Strenght(N/mm^2)	5	0.8848	0.1339	1.0344	0.6843
Deformation at Rupture (mm)	5	2.276	0.3583	2.75	1.75
Total Strain Energy (J)	5	396.2386	72.4442	487.305	292.1625
		Seed Thickness, T			
Bio-yield Force (N)	5	116.55	37.0711	163.8	78.75
Rupture Force (N)	5	129.15	38.1267	185.85	97.65
Compressive Strenght(N/mm^2)	5	0.6525	0.1926	0.9389	0.4933
Deformation at Rupture (mm)	5	2.476	0.5330	3.25	1.75
Total Strain Energy (J)	5	315.1071	103.5567	491.4	244.125

EFFECT OF MOISTURE CONTENT ON THE STATIC COEFFICIENT OF FRICTION OF SELECTED CEREALS AND LEGUMES IN NIGERIA

N.A. Aviara., A. A. Lawal*., S.A. Rimamnuskep and S.A. Adimora

Department of Agricultural and Environmental Resources Engineering, Faculty of Engineering, University of Maiduguri, Maiduguri, Borno State, Nigeria.abulawal2010@gmail.com

ABSTRACT

The static coefficient of friction of soya bean, cowpea, locust bean, maize and milleton four structural surfaces namely glass, galvanized metal sheet, plywood and hesian bag, was determined at different moisture contents using an apparatus operating on the principle of tilting surface. In the moisture ranges of 4.3 to 21.6, 7.4 to 22.4, 4.3 to 14.7, 7.6 to 21.1% (d.b.) the static coefficient of friction of soya bean, cowpea, locust bean, maize and millet increased from 0.361 to 0.481, 0.377 to 0.585, 0.331 to 0.609, 0.367 to 0.502 and 0.331 to 0.613, respectively, and varied with structural surface. Of all the above crops, millet had the highest static coefficient of friction which occurred on plywood, while locust bean and millet had the lowest value on glass surface. The relationship existing between the static coefficient of friction and grain moisture content on specified structural surface was expressed by regression models.

Keywords: soya bean, cowpea, locust bean, maize, millet, static coefficient of friction, moisture content, structural surface, Nigeria

1.0 Introduction

The Nigerian agricultural sector is presently experiencing rapid development, and as a result, farmers are learning to produce crops in commercial quantities. The crops need to be handled, processed and stored as the case may be.

The traditional method of handling, processing and storing the grain include beating of the panicle against a hard element, separation of kernel from cob by thumbs; winnowing with the aid of the wind; metering and packaging in glass or plastic container and conveying to storage structures or markets for sale.Because the aboveoperationsare carried out manually, they result in poor man-hour utilization and losses of grains (FAO,1994). Improved methods of handling, processing and storing the grains using suitable machines and equipment require the knowledge of such engineering properties of grain as static coefficient of friction.

Static coefficient of friction is used to determine the angle at which chutes must be positioned in order to achieve material free flow through the chute (Razavi and Farahmanfar, 2008;Zareiforoush et al., 2009). GhasemiVarnamkhasti et al., (2008) reported that static coefficient of friction is useful in the sizing of electric motors required for grain handling and transportation. Static coefficient of friction has a fundamental application in the determination of pressure exerted by stored products on the walls and floors of storage structures (Mohsenin, 1986;Gumble and Maina, 1990), so it is a useful parameter in the design of storage facilities (Tavakoli et al., 2009b;Seifi and Alimardani, 2010).To estimate the power needed by a power source to start a loaded auger, the coefficient of friction related to the force of static friction that must be overcome is necessary. The coefficient of friction of the material to be chopped is needed in the design of impeller units (Mohsenin, 1986).

Investigators have determined the static coefficient of frictionof grains and seed using several methods and these include moving a given surface against the material (Lawton, 1980), tilting an inclined plane (Mohsenin , 1986; Aviara et al., 1999; Tabatabaeefar, 2003; Zaalouk and Zabady, 2009) and the shear box equipment (Osunade and Lasisi, 1994; Molenda et al., 2000).Brubaker and Pos, (1965),Dutta et al., (1988)and Rusinek and Molenda, (2007) investigated the static coefficient of friction of different grains and noted it to be moisture dependent and to vary with structural surface. Similar findings were reported by Aviara et al., (1999), Zareiforoush et al., (2009), Tavakoli et al., (2009a), Nwakonobi and Onwualu, (2009),Seifi and Alimardani(2010), and Tarighi et al., (2011). The objective of this study was to determine the static coefficient of friction of soya bean, cowpea, locust bean, maize and millet on the glass, galvanized metal, plywood and hessian bag surfaces, and investigate its variation with grain moisture content.

2.MATERIALS AND METHODS

2.1 Sample Collection and Conditioning

For this work, bulk quantities of soya bean and locust bean seeds were procured from Fikyu village, in Ussa Local Government Area of Taraba State, Nigeria. Cowpea, maize and millet were obtained from the Department of Crop Production, University of Maiduguri, Maiduguri,Borno State, Nigeria. The grains were cleaned and sampled for experiments. The initial moisture contents of the grains were determined using the ASABE (2008) standard. This involved oven drying of grain samples at 105^{o}C to constant weight. Grain samples of desired moisture content levels were prepared by conditioning the samples using the method of Ezeike, (1986). This involved soaking of the different bulk samples in clean water for a period of 1 to 3 hours, followed by spreading out in a thin layer to dry in natural air for about 8 hours. Then, the bulk samples were sealed individually in separate polyethylene bags and stored in that condition for a further 24 hours. This allowed for a stable and uniform moisture content of the samples to be achieved.

2.2 Determination of Static Coefficient of Friction

The static coefficient of friction was determined with respect to four structural surfaces namely; plywood, galvanized iron, glass and hessian bag surfaces using the inclined plane method (Dutta et al., 1988,Mohsenin, 1986). This involved placing an open-ended box on an adjustable tilting surface equipment (Figure 1) with the surface formed using a structural material. The box was filled with grain sample and the structural surface with the box and its content on top was gradually raised using a screw device until the box just started to slide down. The angle of tilt was recorded and the static coefficient of friction was calculated using the following equation:

$$\mu_s = \tan\alpha \qquad (1)$$

whereμ_s is the static coefficient of friction and α is the angle of tilt in degrees.

The experiment was conducted on all the grains – soya bean, cowpea, locust bean, maize and millet - at different moisture levels and replicated three times. Data obtained were subjected to analysis of variance (ANOVA) and LSD's test using statistix version 9. Static coefficient of friction was then regressed against moisture content and the function relating it with moisture content for each crop on a structural surface was established.

3.RESULTS AND DISCUSSION

3.1 Grain Moisture Content

The initial moisture content of soya bean, cowpea, locust bean, maize and millet were found to be 4.3, 7.4, 4.3, 7.6 and 7.5% (d.b.) respectively. The three other moisture levels obtained after conditioning the grains were 14.2, 18.2 and 21.6% (d.b.) (soya bean); 15.7, 18.3 and 22.4% (d.b.) (cowpea); 7.6, 12.3 and 14.7% (d.b.) (locust bean); 12.0, 19.1 and 21.1% (d.b.) (maize); and 9.1, 12.8 and 14.6% (d.b.) (millet). Investigations were carried out at the above moisture content levels to determine the effect of moisture content on the static coefficient of friction of the grains.

3.2 Grains Static Coefficient of Friction

The static coefficientsof friction of the grains on four structural surfaces measured at different moisture content levels are presented in Table 1. The variations of static coefficient of friction of the grains with moisture content and structural surfacesare depicted in Figures 2-6.

The F-ratios ofcoefficient of friction for soya bean, cowpea, locust bean, maize and millet obtained from ANOVA arepresented in Table 2. From Table 2, it can be seen that grain moisture content, structural surface and their interaction significantly affected the static coefficient of friction of the grains at 1% level of significance.

3.2.1Soya bean

The static coefficient of friction of soya bean increasedexponentially with increase moisture content within the moisture range of 4.3 to 21.6% (d.b.) on galvanized iron, plywood and hessian bag, while on glass it increased within moisture range 4.3 to 18.2% (d.b.) to a maximum value of 0.419, after which it decreased with further increase in moisture content (Figure 2) and exhibited logarithmic relationship with moisture content. The highest value of 0.481 was obtained on the surface of hessian bagand the lowest value of 0.361 was on glass surface.

The relationship existing between the static coefficient of friction of soya bean and moisture content on different structural surfaces can be expressed using the following equations:

$$\mu_{hbs} = 0.47 + 2.93\times10^{-6} (\text{Exp } 0.383M), \quad R^2=0.997 \qquad (2)$$

$$\mu_{pws}=0.422 (\text{Exp } 0.004M), \quad R^2=0.968 \qquad (3)$$

$$\mu_{gss}=0.412(\text{Exp } 0.004M), \quad R^2=0.865 \qquad (4)$$

$$\mu_{gls}=0.321 + 0.031 (\ln M), \quad R^2=0.912 \qquad (5)$$

where R^2 is coefficient of determination, μ_{hbs}, μ_{pws}, μ_{gss} and μ_{gls} are the static coefficients of friction of soya bean on hessian bag, plywood, galvanized iron sheet and glass respectively, and M is moisture content % (d.b).

3.2.2Cowpea

Figure 3 shows the variation of static coefficient of friction of cowpea with moisture content on different structural surfaces. The static coefficient of friction increased logarithmically with increase in moisture content on all surfaces. The highest value of 0.585 was obtained at 22.4% (d.b.) moisture content on the surface of hessian bag and the lowest value of 0.377 was at 7.4% (d.b.) moisture content on glass surface.

The static coefficient of friction of cowpea on different structural surfaces as related tomoisture content can be expressed using the following equations:

$$\mu_{hbc}=0.22 + 0.116 (\ln M), \quad R^2=0.988 \quad (6)$$

$$\mu_{pwc}=0.108 + 0.141 (\ln M), \quad R^2=0.985 \quad (7)$$

$$\mu_{gsc}=0.196 + 0.093 (\ln M), \quad R^2=0.988 \quad (8)$$

$$\mu_{gsc}=0.181 + 0.101 (\ln M), \quad R^2=0.992 \quad (9)$$

whereμ_{hbc}, μ_{pwc}, μ_{gsc} and μ_{glc} are the static coefficients of friction of cowpea on hessian bag, plywood, galvanized iron sheet and glass respectively.

3.2.3Locust bean

The static coefficient of friction of locust bean increased from 0.331 to 0.488 on glass, 0.367 to 0.577 on galvanized iron, 0.367 to 0.589 on plywood, and 0.470 to 0.609 on hessian bag within the moisture range of 4.3 to 14.7% (d.b.). Thehighest value obtained was at 14.7% (d.b.) on hessian bag and lowest value was at 4.3% (d.b.) on glass (Figure 4).

The relationshipexisting between the static coefficient of friction on the structural surfaces and moisture content was found to be logarithmic and can be expressed using the following equations:

$$\mu_{hbl}=0.335 + 0.104 (\ln M), \quad R^2=0.857 \quad (10)$$

$$\mu_{pwl}=0.141 + 0.165 (\ln M), \quad R^2=0.964 \quad (11)$$

$$\mu_{gsl}=0.159 + 0.155 (\ln M), \quad R^2=0.976 \quad (12)$$

$$\mu_{gll}=0.179 + 0.121 (\ln M), \quad R^2=0.976 \quad (13)$$

whereμ_{hbl}, μ_{pwl}, μ_{gsl} and μ_{gll} are the static coefficients of friction of locust bean on hessian bag, plywood, galvanized iron sheet and glass respectively.

3.2.4Maize

Figure 5 shows the variation of static coefficient of friction of maize with moisture contenton different structural surfaces. The coefficient of static friction increased exponentially with moisture content in the moisture range of 7.6 to 21.1% (d.b.), with the highest value of 0.502 obtained at the moisture content of 21.1% (d.b.) on hessian bag and lowest value of 0.361 at 7.6% (d.b.) moisture content on plywood.

The following equations could be used to express the relationship existing between the static coefficient of friction of maize and moisture content on different structural surfaces:

$$\mu_{hbma}=0.503\ (\text{Exp}\ -1.061/M),\quad R^2=0.725 \qquad (14)$$

$$\mu_{pwma}=0.347\ (\text{Exp}\ 0.004M),\quad R^2=0.945 \qquad (15)$$

$$\mu_{gsma}=0.34\ (\text{Exp}\ 0.011M),\quad R^2=0.999 \qquad (16)$$

$$\mu_{glma}=0.349\ (\text{Exp}0.006M),\quad R^2=0.990 \qquad (17)$$

whereμ_{hbma}, μ_{pwma}, μ_{gsma} and μ_{glma} are the static coefficients of friction of maize on hessian bag, plywood, galvanized iron sheet and glass respectively.

3.2.5Millet

The static coefficient of friction of millet increased logarithmically with moisture content in the moisture range of 7.5 to 14.6% (d.b.) and varied with structural surface (Fig.6). The highest value of 0.613 was obtained at 14.6% (d.b.) moisture content on the surface of plywood and the lowest value of 0.331 at 7.5% (d.b.) moisture contentwas on glass surface.

The relationship existing between the static coefficient of friction of millet and moisture content can be expressed for different structural surfaces using the following equations:

$$\mu_{hbml}=0.061 + 0.197\ (\ln M),\quad R^2=0.792 \qquad (18)$$

$$\mu_{pwml}=-0.081 + 0.255\ (\ln M),\quad R^2=0.96 \qquad (19)$$

$$\mu_{gsml}=0.126 + 0.126\ (\ln M),\quad R^2=0.993 \qquad (20)$$

$$\mu_{glml}=0.072 + 0.133\ (\ln M),\quad R^2=0.996 \qquad (21)$$

whereμ_{hbml}, μ_{pwml}, μ_{gsml} and μ_{glml} are the static coefficients of friction of maize on hessian bag, plywood, galvanized iron sheet and glass respectively.

Table 3 shows the range of variation of static coefficient of friction of the grains with moisture content levels on the different structural surfaces. From Table 3, it canbe seen that locust bean had the widest range followed by cowpea, millet and maize, and soya bean had the narrowest range on all surfaces. This shows that variation in moisture content of locust bean rapidly change the static coefficient of friction, while variation in moisture content of soya bean slowly change the static coefficient of friction. The static coefficients of friction of the grains have the highest values on hessian bag, while the lowest values were on glass surface. Locust bean had the highest static coefficients of friction within the moisture range on hessian bag followed by cowpea, millet, soya bean and maize. Maize had the lowest static coefficient of friction value on glass surface followed by millet, soya bean, locust bean and cowpea.

4. CONCLUSIONS

1. The static coefficient of friction of soya bean, cowpea, locust bean, maize and millet increased with moisture content and varied on structural surface.

2. Millet recorded the maximumstatic coefficient of friction on plywood, while locust bean and millet had the minimum value on glass surface.
3. Locust bean shows rapid change of static coefficient of friction due to moisture content variation followed by cowpea, millet, maize and soya bean
4. The hessian bag recorded the highest value of static coefficient of friction, while glass produces the least values.

REFERENCES

ASABE (2008).Moisture measurement- unground grain and seeds. ASAE S352.2 APR 1988.ASABE Standards, p. 668. American Society of Agricultural and Biological Engineers.2950 Niles Road, st. Joseph, Michigan, www.asabe.org.

Aviara N.A., Gwandzang M.I, and Haque M.A., (1999).Physical properties of guna seeds.Journal of Agricultural Engineering Research, 73: 105-111.

Brubaker, J.E. and Pos, (1965). Determination og static coefficients of grains on structuralSurfaces. Transactions of ASAE 8:53-55

Dutta S.K., Nema V.K., and Bhardwaj R.K., (1988).Physical properties of gram. Journal ofAgricultural Engineering Research, 39: 259-268.

Ezeike G.O.I., 1986. Quasi-static hardness and elastic properties of some tropical seed grainsand tomato fruit. International Agrophysics, 2:15-29.

FAO, (1994).Grain storage techniques - Evolution and trends in developing countries.FAO agricultural Services Bulletin No. 109. FAO, Rome.

GhasemiVarnamkhasti, M., Mobli, H., Jafari, A., Keyhani, A. R., HeidariSoltanabadi, M.,Rafiee, S. and Kheiralipour, K. (2008).Some physical properties of rough rice (oryzasativa) grain. Journal of Cereal Science, 47: 496-501.

Gumble, L. O. and Maina, C. (1990). Friction coefficient of cereal seeds on various surfaces.Agricultural mechanization in Asia, Africa and Latin America, 21(4): 61-64.

Lawton P.J., (1980).Coefficient of friction between cereal grain and various silo wallmaterials. Journal of Agricultural Engineering Research, 25: 75-86.

Mohsenin N.N., (1986). Physical Properties of Plant and Animal Materials. 2nd edition (revised). Gordon and Breach Science Publishers, New York.

Molenda M., Thompson, S. A. and Ross, I. J. (2000). Friction of wheat on corrugated and Smooth galvanized steel surfaces. Journal of Agricultural Engineering Research, 77: 209-219

Nwakonobi, T.U. and Onwualu, A. P. (2009).Effect of moisture content and structural surfaces on coefficient of friction of two Nigerian food grains: Sorghum (sorghum bicolor)and millet (pennisetumglaucum). Agricultural Engineering International: the CIGR ejournalManuscript 1152, volume XI, www.cigrjournal.org

Osunade, J. A. and Lasisi, F (1994). Coefficient of friction of maize and sorghum grains onlaterized concrete wall. NSE Technical Transaction, 29: 50-57.

Razavi, S. M. A. and Farahmandfar, R. (2008). Effect of hulling and milling on the physical properties of rice grains. International Agrophysics, 22: 353-359.

Rusinek, R. and Molenda, M. (2007).Static and kinetic friction of rape seed. Research inAgricultural Engineering, 53(1): 14-19.

Seifi, M. R. and Alimardani, R. (2010). The moisture content effect on some physical and Mechanical properties of corn (sc. 704). Journal of Agricultural Science, 2(4): 125-134.

Tabatabaeefar, A. (2003).Moisture dependent physical properties of wheat. InternationalAgrophysics, 17: 207-211.

Tarighi J., Mahmoudi A., and Alavi N. (2011).Some mechanical and physical properties ofCorn seeds. African Journal of Agricultural Research, 6 (16): 3691-3699

Tavakoli, M., Tavakoli, H., Rajabipour, A., Ahmadi, H. and Gharib-Zahedi, S. M. T. (2009a). Moisture-dependent physical properties of barley grains. International Journal ofAgricultural and Biological Engineering, 2(4): 84-91.

Tavakoli, H., Rajabipour, A., and Mohtasebi, S.S. (2009b). Moisture-dependent of some Engineering properties of soybean grains. Agricultural Engineering Internatioanal: theCIGR ejournal. Manuscript 1110, volume XI, www.cigrjournal.org.

Zaalouk, A. k. and Zabady, F. I. (2009).Effect of moisture content on angle of repose and friction coefficient of wheat grain.Misra Journal of Agricultural Engineering, 26(1):418-427.

Zareiforoush H., Komarizadeh M.H. and Alizadeh M.R. (2009).Effect of Moisture Contenton Some Physical Properties of Paddy Grains.Journal of Applied Sciences, Engineeringand Technology,1(3): 132-139.

Table 1. Static coefficient of friction of some agricultural grains at different moisture contents and on different structural surfaces

		Staticcoefficient of friction (μ_s)			
		Structural surfaces			
Grain type	Moisture cont.% (d.b.)	Glass	Galvanized iron	Plywood	Hessian bag
	4.3	0.361(0.015)	0.424 (0.010)	0.431(0.006)	0.470(0.022)
Soya bean	14.2	0.418(0.006)	0.424 (0.006)	0.442(0.006)	0.470(0.027)
	18.2	0.419(0.018)	0.435 (0.024)	0.452(0.018)	0.473(0.016)
	21.6	0.397(0.012)	0.459 (0.006)	0.463(0.006)	0.480(0.025)
	7.4	0.3770.006)	0.381 (0.006)	0.384(0.020)	0.452(0.012)
Cowpea	15.7	0.473(0.016)	0.456 (0.018)	0.510(0.029)	0.539(0.024)
	18.3	0.477(0.043)	0.473 (0.012)	0.521(0.019)	0.547(0.024)
	22.4	0.481(0.006)	0.480 (0.012)	0.532(0.022)	0.585 (0.014)
	4.3	0.331(0.015)	0.367 (0.007)	0.367(0.021)	0.470(0.016)
Locust bean	7.6	0.473(0.012)	0.513 (0.006)	0.510(0.019)	0.581(0.007)
	12.3	0.477(0.011)	0.524 (0.017)	0.532(0.006)	0.585(0.014)

Grain type	Moisture cont.% (d.b.)	Staticcoefficient of friction (μ_s)			
		Structural surfaces			
		Glass	Galvanized iron	Plywood	Hessian bag
	14.7	0.488(0.019)	0.577 (0.012)	0.589(0.030)	0.609(0.037)
	7.6	0.367(0.021)	0.367 (0.015)	0.361(0.006)	0.438(0.016)
Maize	12.0	0.377(0.006)	0.387 (0.006)	0.404(0.010)	0.463(0.006)
	19.1	0.384(0.017)	0.414 (0.006)	0.422(0.052)	0.449(0.022)
	21.1	0.407(0.012)	0.425 (0.018)	0.414(0.027)	0.502(0.013)
	7.5	0.331(0.015)	0.370 (0.011)	0.418(0.006)	0.428(0.016)
Millet	9.1	0.377(0.006)	0.418 (0.012)	0.510(0.029)	0.539(0.024)
	12.8	0.404(0.018)	0.438 (0.006)	0.547(0.007)	0.562(0.013)
	14.6	0.428(0.006)	0.466 (0.018)	0.613(0.012)	0.578(0.041)

Numbers in parentheses are standard deviations; cont. is content; d.b. is dry basis.

Table 2. F-ratios for the ANOVA of static coefficient of friction of selected grains with moisture content and structural surface

source of variation	F- ratio				
	soya bean	cowpea	locust bean	maize	millet
moisture content (MC.)	52.36*	214.46*	501.92*	28.70*	574.92*
structural surface (SS)	193.28*	242.19*	527.63*	122.11*	612.15*
Interaction MC*SS	9.88*	6.71*	17.95*	4.16*	15.22*

*significant at 1% level.

Table 3. Range of variation of static coefficient of friction due to change in grain moisture content

	Range	of static	coefficient	of friction	
Structural	Soya bean	Cowpea	Locust bean	Maize	Millet
Surface	4.3-21.6% (d.b.)	7.4-22.2% (d.b.)	4.3-12.7% (d.b.)	7.6-21.1% (d.b.)	7.5-14.6% (d.b.)
Glass	0.3658	0.10335	0.15642	0.04008	0.09651
G/iron	0.03476	0.09965	0.21012	0.05723	0.0958
Plywood	0.03142	0.1479	0.22196	0.05369	0.019521
Hesian bag	0.01072	0.1329	0.13929	0.06392	0.14986

G/iron, galvanized iron; d.b., dry basis



Figure 1. Static coefficient of friction apparatus with adjustable tilting surface

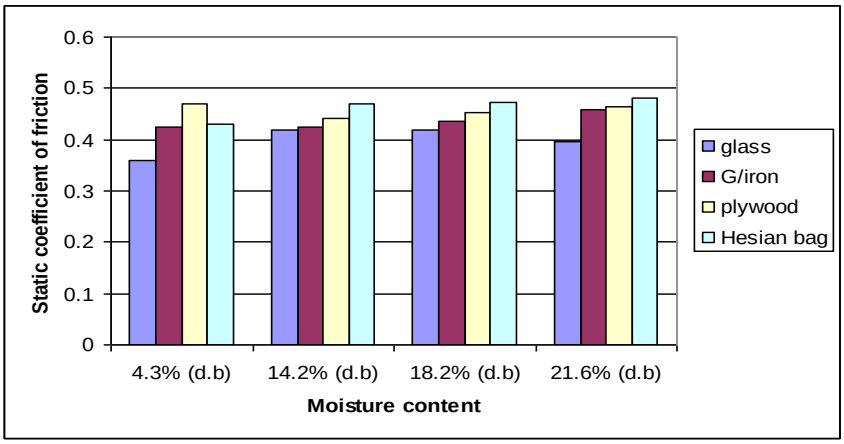


Figure 2. Variation of static coefficient of friction of soya bean with moisture content and structural surface.

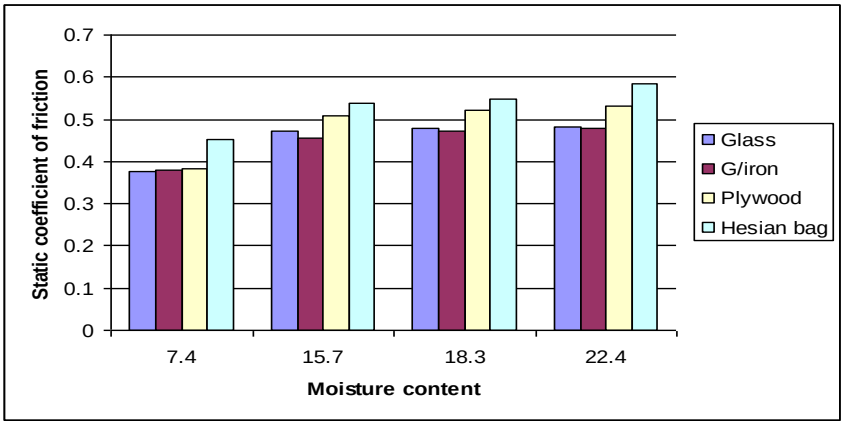


Figure 3.Variation of static coefficient of friction of cowpea with moisture content and structural surface.

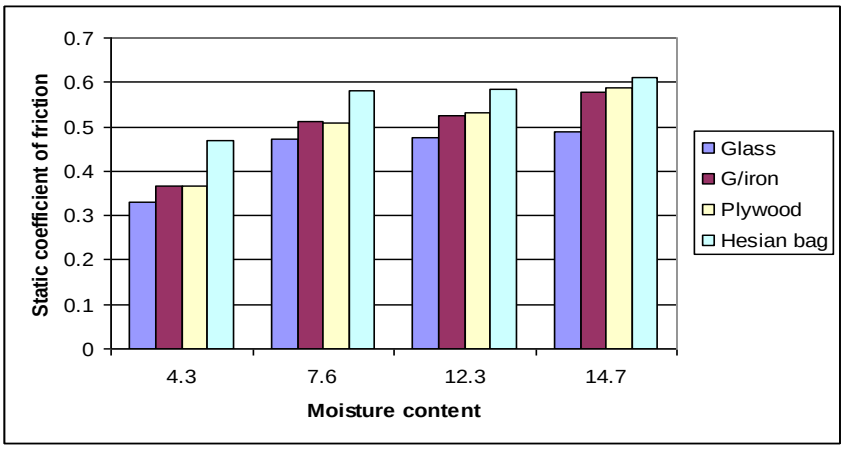


Figure 4.Variation of static coefficient of friction of locust bean with moisture content and structural surface.

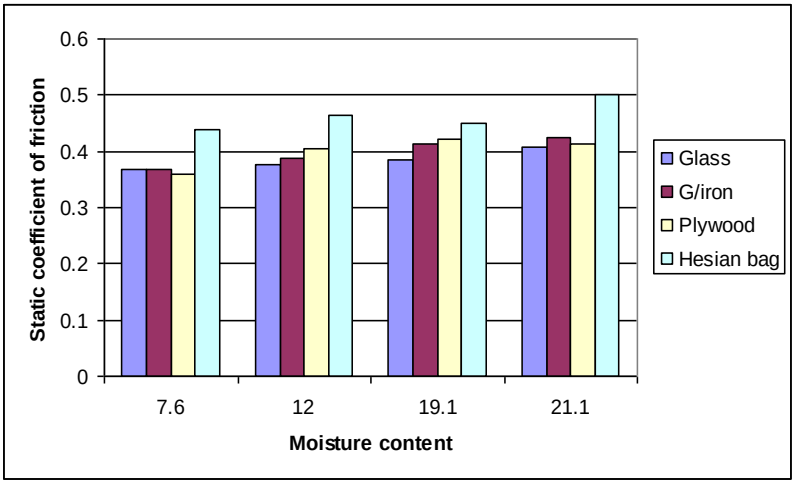


Figure 5.Variation of static coefficient of friction of maize with moisture content and structural surface.

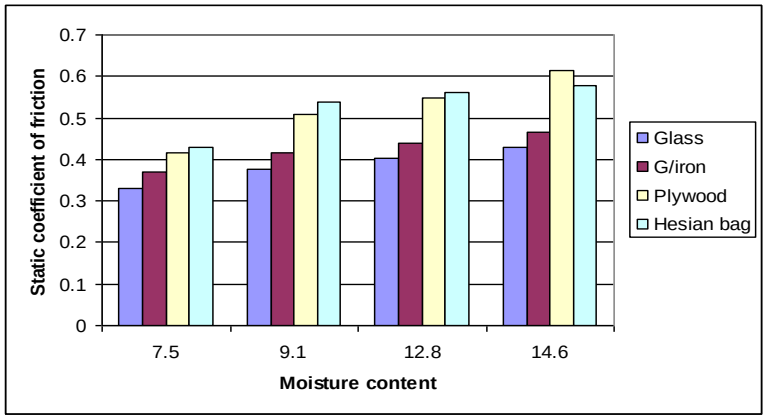


Figure 6.Variation of static coefficient of friction of millet with moisture content and structural surface.

PHYSICAL AND MICROBIOLOGICAL QUALITY ATTRIBUTES OF PACKAGED GARI AT VARIOUS INITIAL MOISTURE CONTENTIN STORAGE

Adejumo,B. A.

Department of Agricultural and Bioresources Engineering, Federal University of Technology, Minna, P.M.B 65 Minna, Niger State Nigeria. bolanleadejumo@yahoo.com

ABSTRACT

The physical and microbiological quality attributes of gari packaged and stored at various initial moisture contents was investigated. Sixty kilograms (60kg) of freshly harvested cassava cultivar common in Nigeria MS6 (*OkoIyawo*) was selected. Gari was produced from the cassava roots using the procedure established and reported by IITA. The initial physical and microbiological properties of the gari were determined within 24hrs of production. The properties determined are the loose bulk density, packed bulk density, pH, total viable bacteria and fungi counts using standard methods. Fifty grams (50g) each of gari was packaged in the polyethylene and hessian bags with unpackaged sample to serve as control. The samples were stored on a shelf at the normal atmospheric conditions which represent the common storage environment for sale of gari. The experimental samples were analyzed monthly for physical and microbiological quality attributes during the storage period. Data collected was analyzed statistically using the SPSS 15.0 statistical package.The results show that the moisture content of gari packaged in hessian bag decrease from the initial moisture content of 17.1 % and 13.1 % to 13.7% and 10.6 % respectively while at 8.6 % initial moisture content, there was an increase to 9.9 % after 12weeks of storage. The initial moisture content and packaging materials has significant effects ($p< 0.05$) on the packed bulk density, swelling capacity and microbiological loads of gari in storage while there was no significant difference in loose bulk density of gariat 8.6 % moisture content packaged in hessian bags. The presence of high percentage of microorganisms in gariwas probably ue to thehigh moisture levels; this will invariably affect the consumption and market value of the product. It is therefore recommended that the actual moisture level of gari before storage should be determined, and suitable packaging materials should be selected in terms of mechanical strength and durability in order to maintain quality and extend the shelf life of the product.

Keywords: Gari, moisture content, hessian bag, polyethylene bag, physicalquality attributes

1.0Introduction

Cassava is a plant originating from South America and is known by botanical name *Manihotesculenta* (Hahn,*et al*., 1992). The roots are used as food source which serves as an important staple in many developing countries of Africa, South and Central America, India, South East and Asia (Balagopalan, 2002). Cassava can grow in poor soil and can withstand drought. It is an important famine reserve crop in countries with unreliable rainfall. Traditionally, cassava roots are processed by a variety of methods into many different food products depending on locally available processing resources, local customs and preference (Balagopalan, 2002). Processing of cassava roots affects the biochemical contents of the resulting products such as gari, *fufu, akpu* and flour (Kemdirim*et al*., 1995).

In gari production, freshly harvested cassava roots are peeled, washed, grated and allowed to ferment for four days, after which the pulp is dewatered, sieved and roasted in an earthen or metal pot to a moisture content of about 12% (Akindanusi, *et al*., 1999). Gari is presented as grains of variable granules size, its ability to store well and its acceptance as a convenience food is responsible for its increase popularity in urban areas of West and Central Africa (IITA, 1990, FAO, 1999, FAO, 2004). The development of micro-organisms in gari is influenced by the high moisture level which leads to great modification in the chemical composition of infected stored gari, as well as discoloration, caking, foul odour, loss in protein content significant changes or increases in free fatty acids and reducing sugars. Presence of micro-organism may also results in the reduction in the market value, shelf-life, palatability of gari, economic value as well as changes in texture and colour.

The effect of different packaging materials on the shelf stability of gari was studied by Ogiehor and Ikenebomeh (2006) using low density polyethylene (LDPE), high density polyethylene (HDPE), hessian bags, and plastic buckets to store gari under tropical ambient temperature for 6months. Results indicated that the total viable bacteria and fungi countincreases gradually from LDPE, HDPE, hessian bags and plastic buckets. Four fungal genera *(Aspergillus, Penicilium, Fusarium and Rhizopus)* and two bacteria genera (*Bacillus, and staphylococcus)* were detected and isolated. Slight decrease was recorded in the pH with a corresponding slight increase in the titratable acidity (TA) in all the packaging materials. Findings and data obtained may be useful in developing indices for shelf stability of gari for possible industrialization.

Effect of moisture content and storage conditions on the storability of gari was investigated by Amadi and Adebola (2008) using yellow and white gari samples obtained from different markets in Ilorin which was stored under the same conditions using polyethylene bags, jute bags, and plastic container. The moisture contents of the yellow and white gari samples were 17.8% and 17.2% respectively. Results showed that moisture content increase with time in the two samples. Mouldiness was also observed in the stored samples. Six mould species were isolated with increasing moisture content. Air-tight polyethylene and plastic containers were observed to preserve gari better than jute bags. Nutrients component and physical properties of gari also depreciated in samples stored in jute bags. The main objective of this work is to evaluate the effect of initial moisture content and packaging types on some physical and microbiological quality attributes of gari stored for three months.

2.0 Materials and Methods

Sixty kilograms (60kg) of freshly harvested cassava root cultivar common in Nigeria MS6 (O*koIyawo*) was selected. Gari was produced from the cassava cultivar using the procedure established and reported by IITA (2003). The production was carried out in the Faculty of Agriculture, Research and Training Unit LAUTECH, Ogbomoso. Matured fresh cassava roots without rots were selected; peeled using knife and the roots were washed in clean water to remove pieces of peels, sand and other dirts. The roots were grated, packed into hessian bag and left for three days to ferment at room temperature. The fermented paste was then placed on a hydraulic jack press to drain the mesh. Using a woven polyester sieve, the drained mesh was sieved to separate the fibrous materials, oversized mesh and also to ensure uniformity of particle size of the mesh. Frying was done in large shallow iron pan over a fire with constant stirring

using a wooden paddle for 20-30 minute. The product was allowed to cool at room temperature of 27^{o}C before packaging.

The initial physical and microbiological properties of the gari were determined within 24hrs of production. Fifty grams (50g) each of gari was packaged in the selected packaging materials: polyethylene bags and hessian bags. The samples were stored on a shelf at the normal atmospheric conditions which represent the common storage environment for sale of gari. Samples were also placed in open container to serve as control. The experiment was carried out using two different packaging types (Hessian and polyethylene bags), 3moisture content and stored for 3months with 3 replicates (2x3x3x3 =54). The experimental samples in storage were analyzed monthly for physical and microbiological properties at three replicates for three months**.**The density, bulk density, swelling capacity and pH were determined as prescribed by IFST (1992).The total fungal and bacterial plate count was determined using the method reported by Steinkraus, 1993.The analysis of variance of the results was determined statistically using the SPSS 15.0 statistical package and the Duncan multiple range test to separate the means.

3.0 RESULTS AND DISCUSSION

3.1 Results

The results of the mean effect of packaging materials and initial moisture content with the separated means are as presented in Table 1. The results shows that there are significant differences ($p \leq 0.05$) in the physical and microbiological quality attributes of gari packaged in different packaging materials at various initial moisture contents in storage.

The packaging materials and initial moisture content had significant effect on the loose bulk density of packaged gari in storage. There was a significant decrease in the loose bulk density of the garipackaged and stored in polyethylene bagsat the initial moisture content of 17.1 and 13.1 %, whileat 8.6 % moisture content, there were increases all through the storage period. The loose bulk density of the samples stored in hessian bag at 17.1 % and 13.1 % decreased all through storage, and at 8.6 % moisture content there was no significant difference.

The packaging materials and initial moisture content had significant effect on the packed bulk density of packaged gari in storage. There weresignificant decreases in the packed bulk density of the gari stored in polyethylene and hessian bags at all the initial moisture content evaluated. The packaging materials and initial moisture content had significant effect on the pH of packaged gari in storage. There were no significant differences in the pH of the gari stored in polyethylene bag at the initial moisture content of 17.1 % but it increasedsignificantly in the samples stored at initial moisture content of 13.1% and 8.6 %. However the pH of the samples stored in hessian bag at 17.1 and 13.1 % increased significantly through the storage period. There were significant differences in the pH of gari stored at 8.6 % initial moisture content all through the storage period.

The packaging materials and initial moisture content had no significant effect on the swelling capacity of packaged gari in storage. There was a significant increase in the swelling capacity content of the gari stored in polyethylene bag at the initial moisture content of 13.1 % while at 17.1 and 8.6 % moisture content there were no significant differences. However there were no

significant differences in the swelling capacity of the samples stored in hessian bag at 13.1 % throughout the storage period.

The packaging materials and initial moisture content had significant effect on the total viable bacteriacounts of packaged gari in storage. There was a significant increase in the total viable bacteria count of the gari stored in polyethylene bag at all the initial moisture content. However, there were no significant differences in the total viable bacteria count of the samples stored in hessian bag at 17.1%, while there was significant increase at 13.1 and 8.6% initial moisture content all through the storage period.The packaging materials and initial moisture content had significant effect on the total fungal count of packaged gari in storage. There was a significant increase in the total fungal count of the gari stored in polyethylene bag at all the initial moisture. However the total fungal count of the samples stored in hessian bag increased significantly at all the initial moisture content all through the storage period.

3.2 Discussion

The moisture content of gari packaged in hessian bag was observed to decrease from initial moisture content of 17.1 % and 13.1 % to 13.7% and 10.6 % respectively, while at 8.6 % initial moisture content, there was an increase to 9.9 % after 12weeks of storage. This is probably due to the hygroscopic nature of gari. However, the analysis of variance (ANOVA) shows that the initial moisture content of gari before storage and the types of packaging materials used have significant effects on the final packed bulked density, swelling capacity and microbiological loads of gari in storage. An initial moisture content of 8.6 % has no significant effects on the loose bulk density of gari packaged in hessian bags.

Gari being hygroscopic in nature absorbs the gases with resultant increase in moisture content which subsequently exacerbate microbial proliferations. The steady but gradual increase recorded in the total viable bacterial and fungal counts in all the samples in the two packaging materials suggests favourable micro environmental conditions and nutrients availability. However, the variation in the counts observed amongst the various packaging materials may be attributed to their relative permeability to atmospheric gases such as oxygen, carbon dioxide and water vapour. These results are similar to reports of Adejumo, 2010;Chuzel and Zakhia, 1991;Ogiehor and Ikenebomeh (2006); Ogiehor and Ikenebomeh (2004).Some of the microorganism isolated includes: *Bacillus sp; Pseudomonas; Staphylococcus sp; Aspergillussp; Candida sp; Geotricumsp; and Rhizopus sp*. In addition, the vast array of fungi species detected and isolated compared to bacteria species may be due to the inability of fungi to tolerate and survive in slightly harsh and environmental conditions (Amadi and Adebola 2008).The decrease in pH observed in all the samples in the various packaging materials at the end of storage and the moisture level period may be related to the activities of the associated microbes.

4.0 CONCLUSIONS

It can be concluded that initial moisture content and the types of packaging materials used will have significant effect on the packed bulk density, swelling capacity, hydrogen cyanide and microbiological loads of gari in storage. Hence it is important to store gari at a low moisture level to prevent deterioration of stored gari. Gari is hygroscopic (it absorbs moisture from the air) in nature and should be packed in air tight and moisture-proof bags, especially in areas of high humidity, to prevent mold growth.The presence of high percentage microbes in gari due to large

amount of moisture content may affect the consumption and market value of the product. It is therefore recommend that the actual moisture level of gari before storage should be determined, and suitable packaging materials should be selected in terms of mechanical strength and durability in order to maintain quality and extend the shelf life of the product.

REFERENCE

Adejumo, B.A (2010). Shelf stability of gari in selected packaging materials. An unpublished Ph.D. thesis, department of agricultural and environmental engineering university of Ibadan, Nigeria.

Akindahunsi, A.A.; Oboh, G and Oshodi, A.A. (1999).Effect of fermenting cassava with Rhizopusoryzae on the chemical composition of its flour and gari.*LaRivista Italiana DelleSostanzeGrasse*, 76: 437-440.

Amadi, J.E and M.O. Adebola (2008).Effect of moisture content and storage conditions on the storability of garri. African Journal of Biotechnology Vol.7(24), PP. 4591 – 4594.

AOAC (1990).Methods of analysis of the Association of Official Analytical Chemists.15th edition. Washington DC. USA.

Balogapalan, C (2002). Cassava utilization in food, feed and industry. I Hillock R.J., Thresh M.J and Bellotti A.C (eds) Cassava: biology, production and utilization. CABI International Oxford PP. 301 – 318.

Chuzel, G. and Zakhia, N. (1991). Adsorption Isotherms of garri for estimation of packaged shelf life. International Journal of Food Science and Technology 26:583 – 593.

FAO, (1999).Food standard programme. Codex Alimentarius Commission XH. Supplements and FAO.Rome Italy.

FAO, (2004).A cassava Industrial revolution in Nigeria. http//www.fao.org/documents/show.accessedon22/05/2006

Hahn, S.K., Reynolds, L and Egbunike, G.N. (1992). Proceedings of the IITA/ILCA/University of Ibadan workshop on the potential utilization of cassava as livestock feed in Africa

IFST, 1992.Shelf – Life of foods – Guidelines for its determination and production.*A Publication of the Institute of Food Science and Technology (U.K).*

IITA (1990).Cassava in tropical Africa, A reference manual.Institute for tropical Agriculture, Ibadan Nigeria.

IITA (2003).Selected laboratory methods.A publication of the International Institute of Tropical Agriculture, Ibadan (Nigeria) Ed. (A.E Okoruwa).

Kemdirim, O.C, Chukwu, O.A. and AchinenwhuS.c (1995).Effect of traditional processing of cassava on the cynaide content of gari and cassava flour. Plant foods for human Nutrition 48:335 – 339.

Ogiehor, I.S and Ikenebomeh M.I (2004). Quality characteristics of market garri destined for consumption in ten selected Nigerian states: baseline for industrialization Advances in Natural and Applied Sciences Research. 2(1): 17 – 25.

Ogiehor, I.S and Ikenebomeh, M. I. (2006).The effects of different packaging materials on the Shelf stability of garri.African journal of Biotechnology vol. 5(23), pp. 2412 – 2416.

Steinkraus, K.H. 1993. *Handbook of Indigenous Fermented Foods*.Microbiology series 9: 273. Marcel Dekkar, New York.

Table 1: The mean[1, 2] effect of initial moisture content on some physical quality attributes of packaged gari in storage

Duration	Parameter	Polyethylene bag			Hessian bag		
		17.1 %	13.1 %	8.6 %	17.1 %	13.1 %	8.6 %
0	Loose Bulk Density	0.45b	0.43a	0.41a	0.45c	0.44a	0.41a
4		0.45b	0.43a	0.40a	0.45b	0.44a	0.40a
8		0.44a	0.43a	0.41b	0.44a	0.43a	0.40a
12		0.44a	0.43a	0.41b	0.44a	0.43a	0.41a
0	Packed Bulk Density	0.57b	0.55c	0.53b	0.57c	0.55b	0.53a
4		0.57b	0.55c	0.52b	0.57b	0.55b	0.52a
8		0.56a	0.54b	0.51a	0.56b	0.54a	0.52a
12		0.56a	0.54a	0.51a	0.56a	0.54a	0.52a
0	pH	3.70a	3.50a	3.60a	3.70a	3.60a	3.60a
4		3.76a	3.60b	3.60a	3.77a	3.60a	3.70a
8		3.70a	3.66b	3.63a	3.73a	3.63a	3.70a
12		3.73a	3.67c	3.70b	3.73a	3.67a	3.80b
0	Swelling Capacity		1.60a			1.60a	
4			1.60a			1.60a	
8			1.60a			1.60a	
12			1.67b			1.60a	
0	Total viable Count	34.00a	18.00a	8.80a		30.00a	9.50a
4		56.00b	18.00a	8.80a		30.00a	9.50a
8		180.00c	36.00b	9.50a		57.00b	9.80a
12		560.00d	45.00c	10.00b		72.00c	18.00b
0	Total Fungal Count	7.30a	3.90a	1.50a	6.30a	4.50a	2.10a
4		10.00b	3.90a	1.50a	7.90b	4.50a	2.10a
8		97.00c	6.40b	4.00b	15.00c	6.00b	5.20b
12		150.00d	8.50c	8.50c	49.00d	7.90c	7.00c

[1] means of three replicate [2] superscript means with the same letters for a particular measurement are not significantly different ($p \leq 0.05$).

A COMPARATIVE ANALYSIS OF THE PERFORMANCE EVALUATION OF TWO ON-FARM FRUITS AND VEGETABLE STORAGE STRUCTURES

Adejumo, B. A.

Department of Agricultural and Bioresources Engineering, Federal University of Technology, Minna, P.M.B 65 Minna, Niger State Nigeria. bolanleadejumo@yahoo.com

ABSTRACT

The performance evaluation of a jute-cane cupboard and a metal-in-block evaporative cooler was carried out with the aim determining the most suitable structure for the storage of some selected fruits and vegetables in south western Nigeria. Freshly harvested oranges, pawpaw, amaranths, pepper and garden egg were procured from a daily market and the samples were weighed separately and divided into three equal parts each. One part each was kept inside the metal - in-block evaporative cooler, jute cane cupboard and plastic basket at ambient storage conditions to serve as control. A digital thermo hygro-meter was used to monitor the daily temperature and relative humidity range inside the metal-in-block evaporative cooler, jute cane cupboard and ambient. All the stored samples were evaluated daily for weight loss, visual freshness and changes in physical qualities. The losses in weight of samples were determined daily by weighing each sample using a weighing balance. The samples showing decay signs were recorded and removed. Generally, cracks, bruise spots, over softening and mould growth were used as indices of deterioration. Cumulative percentage loss was determined until they become puppy or their freshness and quality are lost. The experiment was carried out at three replicates. The results show a temperature range of 25- 32^{o}C, 23-30^{o}C and 26-37^{o}C for the metal-in-block evaporative cooler, jute cane cupboard and ambient conditions respectively. The relative humidity inside the metal-in-block evaporative cooler varies from 74-90 %, 76-93 % in jute cane cupboard and 72-88 % at ambient condition. This shows that the relative humidity inside the jute cane is between 5-20 % higher than ambient condition and 5-15 % higher in the metal-in-block evaporative cooler. There was general increase in weight loss and visual quality as storage days progresses in all the methods evaluated. The fruits and vegetables stored inside jute cane cupboard retained its freshness more than those stored in the metal-in-block evaporative cooler while the least was observed in those stored at ambient condition. The jute cane cupboard preserved orange, amaranth and pepper better in terms of weight loss while the metal-in-block evaporative cooler stored garden eggs and pawpaw better at the end of the storage period. Further work should be carried out to determine the efficiencies of the storage structure in other parts of Nigeria.

Key words: Fruits, vegetables, jute-cane cupboard, metal-in-block evaporative cooler

1.0 Introduction

Fruits and vegetables are important sources of carbohydrates, proteins, organic acid, vitamins and minerals for human nutrition (Irtwange, 2005a, Ayto, 1993). Postharvest begins at the point of separation of the edible part of plants from the parent material and ends when it comes to the possession of the final consumer. Even when this edible parts is detached from it parent parts, metabolic activities still goes on leading to deterioration and losses. Loss means any change in the availability, edibility, wholesomeness or quality of food that prevent it from being consumed by man (Irtwange, 2005b, Holladay, 2001). Postharvest losses in fresh fruits and vegetables may occur anywhere from the point of harvest to the point of consumption. It has been observed that

postharvest losses of fruits and vegetables can be as high as 30 % (Tunde-Akintunde, 2008). The major causes of losses in perishable crops are due to biological, microbiological, chemical and mechanical factors. Other factors includes (i) inadequate harvesting, packaging and handling skills (ii) lack of adequate containers for transport and handling perishables (iii) inadequate storage facilities and transport to market. All these enhance the deteriorations of fruits and vegetables (Irtwange, 2005a, Tunde-Akintunde and Tunde-Akintunde, 2006).

Appropriate postharvest handling can minimize moisture loss, slow down respiration rate and inhibit the development of decay causing pathogens. Temperature and relative humidity is the most important determinant of fresh produce deterioration rate which need to be controlled to extend the shelf life of fruits and vegetables and reduce losses. The rate of deterioration of harvested commodities is generally proportional to the respiration rates and water loss (Tull, 1996, Irtwange, 2005a, Tunde-Akintunde, 2008, Agrodok, 1996). Loss of water results in loss of marketable weight which adversely affects its appearance. The textural quality is reduced by enhance softening, loss of crispness and juiciness and reduction in nutritional quality. Fungi and bacteria are the two main sources of infection that may occur during the growing season, at harvest, handling, storage, transport and marketing or even after purchase by the consumer. These microorganisms can gain entry through wound or natural opening and multiply in the spaces between plant cells. Decay reduction and disease control is through sanitation, careful handling, cooling of produce, use of approved chemicals, physical treatment, biological control, controlled and modified atmosphere (Irwange, 2005a, Irtwange, 2005b, Stern, 2007).

Previous work has been reported on an evaporative cool chamber constructed using baked bricks and river bed sand (Salunkhe *et al*., 1991, Sushmita, *et al*., 2008, Opayele and Olatunji, 2008). It was reported that the temperature inside the evaporative cooler was between 10-15^{o}C lower than outside temperature while the relative humidity was between 30 – 40 % higher than outside. Performance evaluation of the evaporative cooler shows that the weight loss of fruits and vegetables kept inside the chamber was lower than those outside the chamber. The fruits and vegetable were fresh, up to 3-5days more inside the chamber than outside. The evaporative cool chamber does not require mechanical or electrical energy input and can be constructed with locally available materials with unskilled labour. It is economical and can store the fruits and vegetables for 3-5 days with no significant loss. The objective of this work is to carry out a comparative analysis of the performance of a metal-in-block evaporative cooler and jute cane cupboard with the aim of determining the most suitable structure for the storage of some selected tropical fruits and vegetables.

2.0 Materials and methods

2.1 Jute Cane Cupboard

A 1.2 x 0.9 x 0.6 m cane cupboard framed with bamboo sticks and wrapped with jute bag was constructed and use for this experiment. The jute cane cupboard compartment was partitioned into three layers for easy storage of fruits and vegetables as well as to enhance its storage capacity. The base of the structure was elevated to 0.3 m from the ground in order to prevent it from insect pest and rodent attack (Plate 1). A plastic bowl was drilled evenly in eight places at the bottom and filled up with water; this was placed on top of the jute cane cupboard to allow water to drip on the jute bag as well as the stored fruits and vegetables. The jute cane cupboard was placed in the shed so as to protect it from direct sunlight.

2.2 Metal-In-Block Evaporative Cooler

The metal-in-block evaporative cooler was constructed using sandcrete block, mild steel iron sheet and river-bed sand. The design was based on the evaporative cooling effect of a porous body using water. A well ventilated area with overhead shade was selected to harness the advantage of the effect of evaporative cooling. The structure consist of a metal box constructed with mild steel iron sheet having a dimension of 0.90 m × 0.93 m × 0.48 m inserted in a sandcrete block work of 1.2 m × 1.2 m × 1 m. The space between the metal box and the sandcrete block work was filled with riverbed sand. River bed sand covered with jute materials was placed on top the metal box with wooden planks to keep the jute materials in place as well as to prevent heat penetration from the sun (Plate 2). The inner part of the metal box was partitioned into three sections to enhance its capacity. The riverbed sand was kept constantly wet to enhance the cooling of the metal-in-block evaporative cooler.

2.4 Experimental set- up

Freshly harvested oranges, pawpaw, amaranths, pepper and garden egg were procured from a daily market and used for this experiment. The experiment was carried out in the research farm of the Department of Agricultural Engineering Research Farm, Ladoke Akintola University of Technology, Ogbomoso, Nigeria. The samples were weighed separately and divided into three equal parts. One part each was kept inside the metal - in- block evaporative cooler, jute cane cupboard and plastic basket at ambient storage (control) respectively. A digital thermo hygro-meter was used to determine the daily temperature and relative humidity range inside the metal-in-block evaporative cooler and jute cane cupboard as well as the ambient condition. All the stored samples were evaluated daily for weight loss, visual freshness and changes in visual quality. The losses in weight of samples were determined daily by weighing each sample using a weighing balance and the percentage loss in weight calculated. The samples showing decay signs were recorded and removed. Generally, cracks, bruise spots, over softening and mould growth were used as indices of deterioration. Cumulative percentage loss was determined until they become pulpy or their freshness and quality was lost. The experiment which lasted for seven days was carried out at three replicates each.

3.0 Results and Discussion

3.1 Temperature and Relative Humidity Variation

The results show that there are variations in temperature and relative humidity of all the storage structures evaluated during the storage period of 7 days. The temperature range inside the metal-in-block evaporative cooler varied from 25- 32^{o}C, 23 - 30^{o}C in the jute cane cupboard and 26 - 37^{o}C at the ambient condition. The relative humidity inside the metal-in-block evaporative cooler varies from 74 – 90 %, 76 - 93 % in the jute cane cupboard while it ranged between 72 – 88 % at the ambient condition. This shows that the relative humidity is between 5 -20 % higher in the jute cane cupboard and 5 - 15 % higher in the metal-in block evaporative cooler than the ambient condition. The higher relative humidity and lower temperatures in the jute cane cupboard and metal-in-block evaporative cooler is as a result of the evaporative cooling effect of the moisture in the two porous materials this result is similar to the reports of Salunkhe *et al.*, 1991 and Sushmita, *et al.*, 2008.

3.2 Changes in Visual Quality

The results of changes in the visual qualities of the various fruits and vegetables stored are as presented in Table 1. There were changes in the visual qualities of all the fruits and vegetables stored in all the storage methods evaluated, this result is similar to previous report that all fruits and vegetables deteriorate once detached from their parent material (Irtwange, 2005a, Irtwange, 2005b, Tunde-Akintunde, 2008, Ocados vegetables, 1998, Tull, 1996). For all types of fruits and vegetables stored it was observed that the freshness and firmness (finger feel) was better for those stored in jute cane cupboard and metal-in-block evaporative cooler than those stored at ambient conditions. Amaranths lost its tenderness within 2 days of storage at the ambient conditions at a temperature and relative humidity range of 26 - 37^{o}C and 72 - 88% respectively. The oranges, pawpaw, pepper and garden egg became soft and pulpy within 3 to 5 days of storage at the ambient conditions with a temperature and relative humidity range of 26 - 37^{o}C and 72 - 88% respectively Plate 3.

However in the metal-in-block evaporative cooler, amaranth retained its freshness and tenderness for a period of four days but became wilted on the sixth day of storage in a temperature and relative humidity range of 25 – 32^{o}C and 74-90 % respectively Plate 4. The orange stored in the metal-in-block evaporative cooler was hard and fresh up to the 7th day of storage while the pawpaw was hard till the 4th day at a temperature and relative humidity ranges of 25-32^{o}C and 74 – 94 % respectively. The pawpaw however became soft and pulpy within the 5th and 7th day of storage. The garden egg was also fresh till 4th day but became dry and yellowish in colors on the 5th day of storage at a temperature and relative humidity range of 25 – 32^{o}C and 74-90 % respectively while the pepper was hard and fresh up to the 5th day Plate 5. The temperature and relative humidity range of 25-32^{o}C and 74 – 90 % obtained in the metal-in-block evaporative cooler seems to favor the storage of orange, pawpaw, pepper, garden egg and amaranths for a period of four days with minimal changes in visual qualities. In jute cane cupboard, the amaranth stored retained its tenderness and freshness for a period of five days but lost its tenderness on the 6th day of storage at temperature of 23 - 30^{o}C and relative humidity of 76 – 93 % Plate 6. The orange, pawpaw and pepper stored in jute cane cupboard were still hard and fresh till the 7th day of storage (Plate 7) while the garden eggs were also fresh till the 5th day but however became yellowish in color on 6th day of storage Plate 8.

3.3 Weight Loss during Storage

The results of the percentage loss in weight of all the fruits and vegetables stored in metal-in-block evaporative cooler and jute cane cupboard as well as in ambient storage are as presented in Figure 1. There was a general loss in weights of all the fruits and vegetables in all the storage methods used; this is probably due to the loss of moisture resulting from the respiration and transpiration process in the stored products (Irtwange, 2005b, Tull, 1996). The results showed that the jute cane cupboard will preserve orange, amaranth and pepper better in terms of weight loss while the metal-in-block evaporative cooler will store garden eggs and pawpaw better at the end of the storage period. The variations in the percentage loss in weight were probably due to the various characteristics of the physical properties of the different types of fruits and vegetables enhanced by the variations in the temperature and relative humidity in the various storage structures.

4.0 CONCLUSION

The jute cane cupboard cooler had lower temperature and higher relative humidity than the metal-in-block evaporative cooler. Jute cane cupboard gives the most appropriate storage condition for storing of orange, pepper and amaranths at temperature of 23-30^{o}C and relative humidity of 76 – 93 % in terms of minimal changes in visual quality and loss in weight. The metal-in-block evaporative cooler however stored pawpaw and garden egg better than the jute cane cupboard for the period of storage evaluated. Further work should be carried out to determine the efficiencies of the storage structure in other parts of Nigeria.

REFERENCE:

Agrodok - Series No3, (1996).” Preservation of fruit and vegetable” Pg8.

Ayto, J. (1993). Dictionary of world origins. New York Arcade Publishing.

Holladay, (2001): “A swamp cooler cools air by evaporation”. Wonder Quest Weekly Q&A science column. USAToday.com. http://www.wonderquest.com/swamp_coolers.htm. Retrieved on 2006-07-14.

Irtwange, S. V. (2005a). Application of modified atmosphere packaging and related technology in postharvest handling of fresh fruits and vegetables. Proceeding of the 6th International Conference and 27th Annual General Meeting of the Nigeria Institution of Agricultural Engineers. 27: 226-235.

Irtwange, S. V. (2005b). Maturity, quality and marketing of fruits and vegetables. Proceeding of the 6th International Conference and 27th Annual General Meeting of the Nigeria Institution of Agricultural Engineers. 27: 236-242.

Ocado’s vegetable offering. (1998). Retrieved from http : // enwikipedia. org/wiki/ vegetable.

Opayele, E.O. and Olatunji, O.K., (2008). “Comparative Study of Fruit and Vegetable in the evaporative cool chamber and in ambient. Unpublished B.Tech thesis, Department of Agricultural Engineering, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

Salunkhe, D. K, Bolin, H.R, Reddy, N .R. (1991). Storage, processing and nutritional quality of fruits and vegetables. Boca Ration, FL USA; CRC press Inc.

Stern, K.R. “Fruit” Microsoft @ student 2007 (DVD)

Sushmita M.D., Hemant, D. and Radhacharan, V. (2008). “Comparative study on storage of fruits and vegetables in evaporative cool chamber and in ambient”. International Journal of Food Engineering, 4 (1): 2-12

Tull, A. (1996). Food and Nutrition. Oxford University Press. Pg 21-33

Tunde-Akintunde, T.Y and Tunde-Akintunde, B.O. (2006). Postharvest losses of food crops: sources and solutions. Proceedings annual conference of the Nigerian society of agricultural engineers. 18: 258-261.

Tunde-Akintunde, T.Y (2008). Effect of soaking water temperature and time on some rehydration characteristics and nutrient loss in dried bell pepper. Agricultural Engineering International: the CIGR Ejournal. Manuscript FP 08 013. Vol. X. October, 2008.



Plate 1: Jute Cane Cupboard



Plate 2: Metal–in–Block Evaporative cooler



Plate 3: Orange, pawpaw, garden egg and pepper on the 5th day of storage at ambient condition



Plate 4: Amaranths on 6th day of storage in metal-in-block evaporative cooler



Plate 5: Orange, pawpaw, garden egg and pepper on the 5th day of storage in metal-in-block evaporative cooler



Plate 6: Amaranths on the 6th day of storage in jute cane cupboard



Plate 7: Orange, pawpaw and pepper on the 7th day of storage in jute cane cupboard



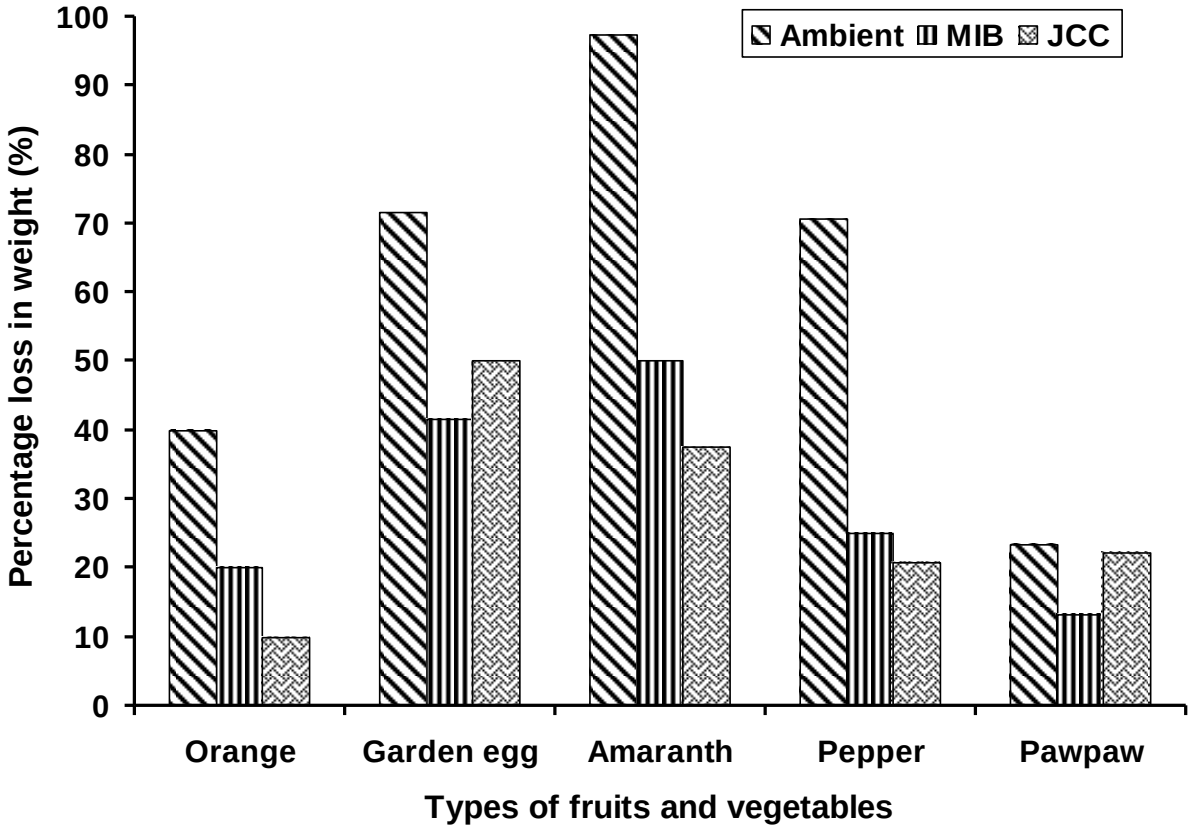
Plate 8: Garden egg on the 6th day of storage in jute cane cupboard

Table 1: Changes in Visual Quality of Fruits and Vegetables during Storage

Product	Storage condition	Days of storage						
		1	2	3	4	5	6	7
Orange	Metal-in-Block	4	4	4	4	3	3	3
	Jute-cane cupboard	4	4	4	4	3	3	3
	Ambient	4	4	4	3	2	1	1
Garden	Metal-in-Block	4	4	3	3	2	2	1
Egg	Jute-cane cupboard	4	4	4	3	3	1	1
	Ambient	4	4	2	2	1	-	-
Amaranths	Metal-in-Block	4	4	3	3	2	2	1
Jute-cane cupboard		4	4	4	4	3	3	3
	Ambient	4	3	2	1	-	-	-
Pepper	Metal-in-Block	4	4	4	4	4	3	2
	Jute-cane cupboard	4	4	4	4	4	3	3
	Ambient	4	4	3	2	2	1	-
Pawpaw	Metal-in-Block	4	4	4	3	3	2	2
	Jute-cane cupboard	4	4	3	3	2	2	1
	Ambient	4	4	2	2	1	-	-

Rating Indices:

Leafy vegetables:	Fruits and other vegetables:
4: fresh and tender	4: hard
3: fairly tender	3: firm
2: wilted	2: fair firm
1: wilted and dry	1: pulpy and soft



***MIB= Metal in block evaporative cool; JCC = Jute cane cupboard**

Figure 1: Weight loss in fruits and vegetables stored in two on-farm storage structures

DEVELOPMENT OF A DOUM PALM HUSKING MACHINE

O.K. Fadele[1*], M. Obochi[1] and N. E. Onwuegbunam[2]

[1]Department of Agricultural Engineering, Federal College of Forestry Mechanization Afaka Kaduna Forestry Research Institute of Nigeria.fadeleseyi@yahoo.com,+ 2348064487957
[2]Basic Science Department, Federal College of Forestry Mechanization Afaka Kaduna Forestry Research Institute of Nigeria.

ABSTRACT

Doum palm fruit, the fruit of interest in this work, is a potent source of anti-oxidant. It grows mostly in African countries. It is a fruit with great potentials and this has necessitated the development of a machine that can be used to process the fruit. In this work the performance evaluation of a doum palm husking machine was considered.The doum palm husking machine was assessed based on its efficiency and capacity using the fruit in its natural state. The percentage total husk present in the fruit was also found in orderto evaluate the efficiency of the machine. Moreover, the efficiency of the machine was found to be 80.20% with a capacity of 2.754 kg/hr on mass basis while on fruit basis it was found to be 124 fruit/hr. The value obtained for the capacity indicated that the doum palm fruit worked on124 fruit for an hour to get a husk of 0.438kg. This is quite acceptable even though it is small. However, the capacity of the machine is seemingly low while its efficiency is high. The low value obtained for the efficiency could be improved upon by increasing size of the machine. It is therefore recommended that in the subsequent study of this work, parameters relating to both the fruit and machine should be varied to improve upon its capacity.

Keywords: doum palm, husk, efficiency, capacity

1.0 Introduction

Doum palm fruit (*Hyphaene thebaica*) belongs to the palm family which is distinguished from all other palm of West Africa by its forking stem; its mesocarp smell and taste like ginger hence it is referred to as ginger bread in some places.It also grows very well in the northern part ofNigeria. It is a member of the palm family, Arecaceae.The trunk of this small palm commonly branches into twolike Y and often each branch divides again in a Y form,giving the tree a very distinctive appearance; it isdichotomous and arborescent in nature. It is listed as oneof the useful plants of the world (Fletcher, 1997; Aremu and Fadele, 2011; Doren, 1997). It grows up to a height of 6.9m and can only be propagated from seeds;this is similar to other members of the palm family. The aqueous extract from the fruit has been reported to have significant antifungal properties. Doum palm fruitis also a source of potent antioxidants.The fruit has a brown outer fibrous flesh which is normallychewed and spewed out. Doum palm kernel is ediblewhen it is unripe but hard when it is ripe.The husk fromthe fruit can be pounded to form powder or cut off inslices; the powder is often dried then added to food asa flavouring agent. (Irobi and Adedayo, 1999; Hsu et al., 2006; Aremu and Fadele, 2011; Orwa et al., 2009).

Manual husking of palms is usually a very strenuous process due the nature of the fruit. The process is tasking and difficult. It is also time consuming and ineffective (Jarimopas et al., 2009a; Jarimopas et al., 2009b).It will be necessary to mechanize the production of doum palm husk so as reduce drudgery and enhance timeliness. The objective of this work is to construct a doum

palm husking machine to revolutionize and facilitate doum palm husk production. This will further enhance the use of the husk in poultry feed, having discovered that it can be used to supplement poultry feed, it will also enhance the extraction of important compounds (antioxidant) present in the fruit husk.

2.0 MATERIALS AND METHOD

2.1 Materials

The machine was designed to husk or remove the back of doum palm fruit (*Hyphaene thebaica*) using abrasive method of husking. The materials that were used in the construction of machine were sourced locally. The frame of the machine was made of mild steel to provide rigidity. It was made portable and easily fixed together, thus allows for compactness and also local artisans would be capable of fabricating the machine.

2.2 Machine Description and Working Principles

The doum palm husking machine consists of the following components namely hopper, frame, pulley, bearings, sharp edge spikes tooth cylinder, belt and electrical motor. Two inch concrete nail was selected for fabricating the sharp edge spike tooth cylinder (SESTC). The nails was welded to a rotating hollow pipe (plate 1). The machine is driven by a 5 hp electric motor. A pyramid hopper was designed to hold the doum palm before husking. The hopper was constructed from mild steel plate. The husking operation takes place in the husking tunnel which comprises of the working mechanism which is the SESTC. The sharp edge spike tooth was fabricated from K-type nails having a length of 2cm and two cylinders pipe of different diameter. The bigger cylinder was perforated with the nails being inserted into it while the second cylinder was used to hold the nails in place. The shaft bears the welded spikes and cylinders; it facilitates transmission of motion from the prime mover. The shaft is seated on two bearings with pulley driven by an electric motor through the belt. The machine frame (support) was constructed from angle bar having a thickness of 1.5mm. The dimension of the angle is 45mm × 45mm. This specification was used so as to reduce vibration as well as ensuring rigid support during operation.The Discharge Outlets allow for release of doum palm nut and husk during and after the husking operation. The discharge outlet for doum palm nut has a gate which retains the fruit in the hopper during operation. The gate is immediately opened after the husking process to allow the husked nut to be discharged. The second discharge outlet enhances the release the husk during operation.

The pictorial view of the doum husking machine is shown in plate 2. Total equipment height is 110mm while the breadth and the width are 62 mm and 36 mm respectively as shown in figures 1, 2 and 3. These values indicate the space and area the machine would occupy. The hopper size was found to have a space which could contain 150 doum palm fruits.

The doum palm husking machine applies abrasive force in husking through the sharp edge spike-tooth cylinder. The perpetual contact of the mechanism with the fruit brings about the removal of the husk. Plates 3 and 4 show the husked fruit and its husk respectively.

2.3 Performance Evaluation of Doum Palm Husking Machine

The doum palm husking machine was subjected to some tests to determine its function. The following parameters were found to ascertain the performance of the machine.

2.3.1 Percentage Total Husk of Doum Palm Fruit

Ten matured doum palm fruits were randomly selected and weighed and their masses (M_n)were recorded. The fruits were then manually masticulated to remove the fruit husk. The masses of the fruit nuts (M_{2n}) were then recorded. The proportion by weight of husk in the fruit (W_p) was computed using the formulabelow:

$$W_p = (M_n - M_{2n}) \div M_n \quad (1)$$

(Adetan *et al.*, 2003)

2.3.2 Efficiency of Doum Palm Husking Machine

The efficiency was evaluated using the following formula in equation two.

Efficiency = [(Mass of fruit before husking – Mass of fruit after husking)/ Initial Mass of Fruit – Mass of Fruit Nut] (2)

2.3.3 Capacity of Doum Palm Husking Machine

The capacity of the machine was found by weighing a specified quantity of the fruit before the husking operation. The capacity was evaluated using the following formula in equation three.

Capacity = Mass of Fruit before husked/ Time taken for husked (3)

The capacity was also be found on the basisnumber of fruit husked per hour, the formula is given as follow in equation four:

Capacity = Number of fruit husked/ Time taken for husked (4)

3.0 RESULTS AND DISCUSSION

3.1 Percentage Total Husk of Doum Palm Fruit

Mean percentage total husk of was determined and found to be 39.57 % with a range of 33.33 – 44.44%, at a moisture content of 51.12%. This values are useful for computing mean mass of doum palm nut, which could is used to compute husking efficiency of the equipment. A good portion of the fruit is made up of the husk, indicating a potential for obtaining large quantity of husk from the fruit. This could be used to substitute good portion of some constituent in poultry feed. The husk could also serve as a good source of antioxidant because the percentage of husk present in the fruit is economical.

3.4 Efficiency of Doum Palm Husking Machine

Mean husking efficiency was found to be 80.20% when the fruit was husked in a fresh state at moisture content of 51.12%. This value is quite high for a machine. The value obtained for the efficiency of the machine could be as a result of sharpness of the spikes on the working mechanism.

3.5 Capacity of Doum Palm Husking Machine

The capacity of the doum palm husking machine was found to be 2.754 kg/hr while or 124 fruit/hr, which translates to 0.438kg/hr husk removal rate.

4.0 CONCLUSIONS

The doum palm husking machine worked effectively even though the capacity was low but the efficiency was acceptable. The information obtained about the doum palm fruit husking could be an underlying fact to design of a more effective husker for the fruit. It was obvious that the sharp edge spike tooth cylinder was appropriate as working mechanism for doum palm fruit husking. This would work more effectively if a higher torque is applied. The doum palm husking machine was assessed to be efficient. The construction work of the machine was adjudged to be properly fabricated. However, in order to improve on the efficiency of the machine. It is recommended that the machine should be critically assessed by varying the condition of the fruits and parameters such speed and feeding rate during performance evaluation. So also the mode of fruit loading should be considered and re-examined to improve upon the capacity of the machine.

REFERENCES

Adetan, D.A., Adekoya, L.O. and Aluko, O.B. 2002. Characterisation of some Properties of Cassava Root Tubers. *Journal of Food Engineering. Elsevier.* 59 (2003) 349–353.

Aremu, A.K. and Fadele,O.K. (2011). Study of some properties of doum palm fruit (*Hyphaene thebaica*) in relation to moisture content.African Journal of Agricultural Research.Academic Journals. Vol. 6(15): 3597-3602.

Doren, E.T. (1997). Vegetable ivory and other palm nuts/seeds. Art/craft Medium. Journal ofInternational palm society, vol. 41 (4) Pp 18-25.

Fletcher, R. (1997). Listing of useful plants of the world. Australian New Crops http://www.newcrops.uq.edu.au/listing/hyphaenethebaica

Irobi ON, Adedayo O (1999). Antifugal activity of aqueous extract of dorminant fruit of Hyphaene thebaica. Pharmaceut. Biol (formerly, Int. J. Pharmacog.) 37: Pp 114-117.

Hsu, B., Coupar, I.M. and Ng, K. (2006). Antioxidant activity of hot water extract from the fruit of the Doum palm, Hyphaene thebaica. Food Chemistry. Elsevier Science Direct. Vol.98:317 – 328.

Jarimopas, B. Ruttanadat, N. and Terdwongworakul, A. (2009a). An automatic trimming machine for young coconut fruit. Elsevier Science Direct. Biosystem Engineering. Vol. 103: 167 – 175.

Jarimopas, B., Niamhom, S. and Terdwongworakul, A. (2009b). Development and testing of a husking machine for dry betel nut (Areca Catechu Linn.). Elsevier Science Direct. Biosystem Engineering. Vol. 102: 83 – 89.



Plate 1: Sharp Edge Spike Tooth Cylinder



Plate 2: Doum Palm Husking Machine

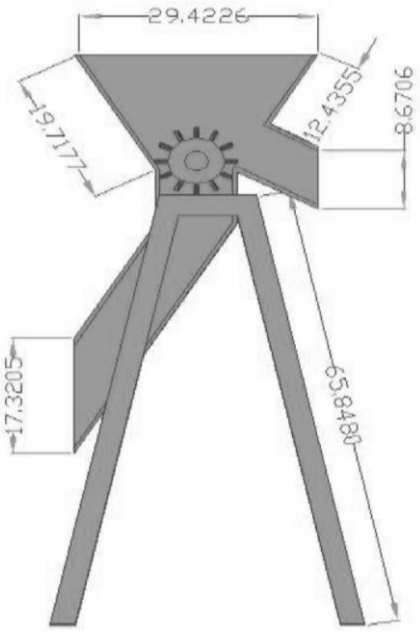


Figure 1: Side View of the Doum Palm Husking Machine

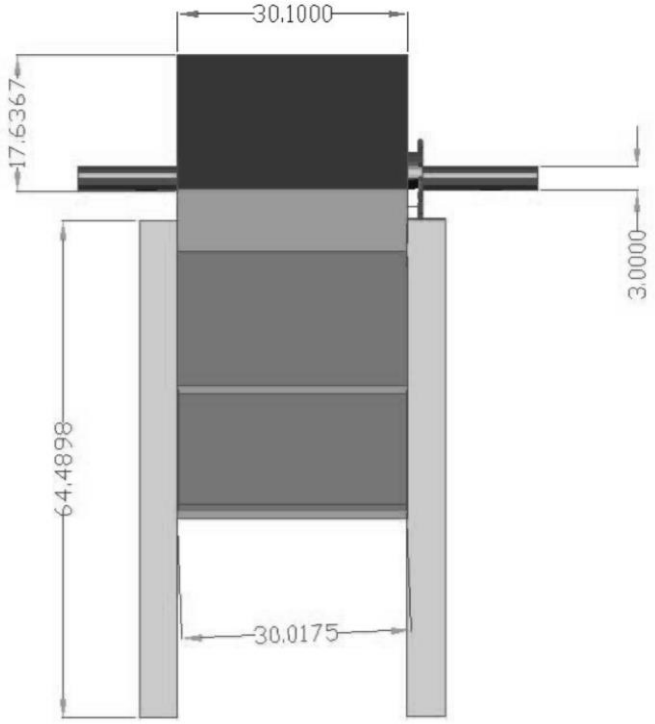


Figure 2: Front View of the Doum Palm Husking Machine

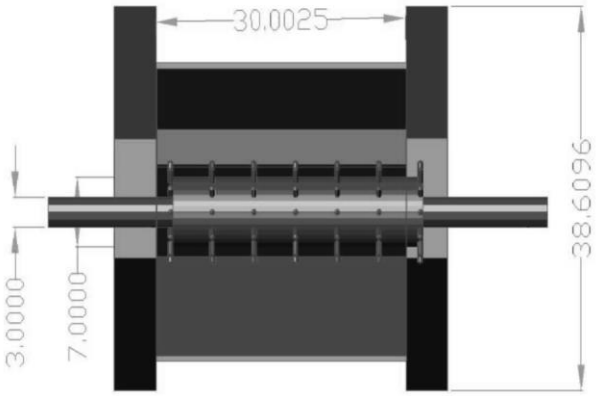


Figure 3: Plan of the Doum Palm Husking Machine



Plate 3: Husked Doum Palm Fruit



Plate 4: Doum Palm Husk

DEVELOPMENT OF AN IMPROVED MOTORIZED OIL PALM FRUIT BUNCH STRIPPER

Olotu, F.B[1]andObiakor, S.I[1]

National Centre for Agricultural Mechanization (NCAM), Km. 20 IlorinLokoja Highway, Idofian, Kwara State, Nigeria.bosedeakande@yahoo.com; siobiakor4ever@yahoo.com

ABSTRACT

The problems affecting the performance of the NCAM oil palm fruit processing system were identified in an earlier work, Obiakor (1998). In this system, stripping of the fruit lets from the Spike lets was done manually by hand picking with the attendant bruise or injury to the fingers of the processors. These pose serious discomforts and constitute a major bottleneck or hindrance in the use of the NCAM oil palm fruit processing system and generally to the small scale oil palm processing industries where this system is used. Thus the need to develop a low-cost mechanical oil palm fruit stripper which will be an improvement on the existing strippers, and which removes the bottleneck in the NCAM oil palm fruit processing system became imperative. Consequently, an improved motorized oil palm fruit bunch stripper was developed.

The preliminary test carried out on the stripper showed that the stripper has strip ability between 96.75% and 99.56%indicating that the stripper effectively strips the fruit lets from the bunches. The clean fruit recovery percentage is between 90.91% and 99.73% indicating that little or none of the fruitlets is lost during the stripping operation.

The feed rate of the stripper ranges between 324.75kg/hr and 418.48kg/hr while it's output capacity ranges between 231.66kg/hr and 323.12kg/hr. These results showed that the stripper will be able to handle up to two tonnes of oil palm fruit bunches in an-8hr- a day operation which makes it suitable for the small-medium scale oil palm fruit processing industries.

Keywords: Development, Design, Oil palm, Stripper

1. Introduction

Modern processing of oil palm fruit bunches into edible oil is practiced using various methods, which may be grouped into four categories according to their throughput and degree of complexity. These are the traditional methods, small-scale mechanical units, medium-scale mills and large industrial mills.

Generally, processing units handling 1- 2 tonnes of fresh fruit bunches (FFB) per hour are considered to be small-scale. Installations that process between 2 and 8 tonnes FFB per hour are termed medium-scale, while large-scale mills process up to 10 tonnes or more per hour. Much has been written about traditional technologies and medium- and large-scale mills, but information on small-scale processing units is scarce. According to(FAO, 2001) the historical reason for the ready availability of information on medium- to large-scale operations and machinery is that most developmental work was undertaken in Europe. Machinery manufacturing is a recent development in the West African sub-region, and until recently it has not been possible to develop the sophisticated machines required to improve on traditional methods. Machinery manufacture in Africa must be carefully considered if progress is to be made in joining the rest of

the industrialized world. Even now it is difficult to manufacture bolts and coiled springs in the Central and West African sub-region and the required type of machinery and equipment that provides optimum performance, energy and water consumption. It is agreed that traditional methods of extracting palm oil from the palm fruits were inefficient and tedious for producing palm oil for export.

Generally women in the villages are responsible for the processing and sale of farm produce. Small-scale agro-processing seems to hold the key to rural poverty reduction and the prolific oil palm tree provides the best raw material for starting rural industries. Today small-scale processors, who appreciate the value of using machines, are asking for them to be more sophisticated. Thus, current demand for small-scale palm oil mills is shifting from simple stand-alone unit operational machines to a more integrated system which is easy to operate and maintain. Machinery manufacturers have responded with machines that combine several operations into one machine unit. The complete range of operational machines – covering bunch stripping, fruit sterilization, digestion, pressing, clarification, oil drying and storage have been developed for small-scale processing applications. The processors can change and/or combine equipment to suit their purchasing power. (FAO, 2001)

The justification for the project was based on the problems identified in the performance of the NCAM oil palm fruit processing system in an earlier work by Obiakor, (1998). In this system, stripping of the fruitlets from the Spikelets was done manually by hand picking with the attendant bruise or injury to the fingers of the processors. These pose serious discomforts and constitute a major bottleneck or hindrance in the use of the then NCAM processing system. There was the need, therefore, to develop mechanical oil palm fruitlet strippers to remove the above bottleneck in the NCAM oil palm fruit processing system. This project is to fulfill this need and to make an improvement on the existing strippers

The aim of the palm fruit stripper is to detach fruitlets from the sterilized bunches or spikelets and there are two main types of strippers that are found in practice. These are the beater arm stripper and the rotary drum stripper. Some of the institutions where these types of stripper can be found were visited by the author in order to develop an improved prototype.

Of the many types of stripping machines that have been developed, only two have been found to give satisfactory performance in practice. According to Gebr Stork (1960) the two types are the beater arm bunch stripper mostly used in mills of up to 4 or 5 tons ffB/hr. through put, and the rotary drum stripper(thresher) commonly used in mills where greater throughout are to be handled.

Suryanto and Bardaie (1996) reported that drum type threshers are now widely used in stripping or threshing agricultural products.
In Nigeria, a mechanized system of stripping oil palm fruit bunches consist of a rotating drum or fixed drum equipped with rotary beater bars which detach the fruit from the bunch, leaving the spikelets on the stem. These strippers are available in NIFOR Benin. (FAO, 2001), goggle search).

CIAE (1987) developed both manual and motorized strippers for stripping groundnut pods from the plant. The motorized version consists of 400mm diameter, 1000mm long horizontal rotor

rotating at 3000rpm and powered by a 1.5hp electric motor. Four rows of nails placed at the periphery of the rotor strip the pod from the plant. The efficiency of stripping was 90% with only 5% pod breakage.

Gebr Stork (1960) developed rotary drum threshers for stripping fruits from fresh fruit bunches (ffB), which consisted of a long cylindrical drum made up of small section channel bars, arranged at equal intervals. The clearance between any two bars is sufficient for the released fruit to drop through but not enough for the empty ffB to pass through. The drum diameter varied from 1.8 to 2.0 metres and the length from 3 to 5metres. The ffB are carried round the drum by interplay of gravity and centrifugal forces, and as the movement is repeated many times, the fruitlets are stripped off the ffB.

If the rotary thresher is to strip efficiently, the speed at which the drum revolves should be such that the spikelets are carried up to a given height and do not keep rolling about at the bottom, nor taken round with the drum owing to excessive centrifugal force. Gebr stork (1960) further gave the following empirical formular for the determination of the speed of drum necessary to provide efficient fruit stripping:-

$$n = \sqrt[40]{\frac{(D-d/2)}{D-d}} \text{----------(1)}$$

Where n= the required rpm of the drum
d = the smallest diameter of the bunch/spikelet measuredover the thick part, metres.
D= the inside diameter of the rotating drum metres.

Suryanto and Bardie (1996) developed an experimental drum thresher to detach oil palm fruits mechanically from fruit bunches (ffB) and cut spikelets prior to transportation to the mill. They reported that the percentage of stripped fruits could be increased by increasing the rotational speed and decreasing the inclination angle of the inner drum but that increasing the inner drum speed and diameter will increasethreshing power requirement. They also found that drum speed do not significantly affect the fruits bruise index for each drum diameter. Bruise index of less than 4.0 was obtained in their work and fruits with these bruise indices could only produce crude oil of free fatty acid (ffA) of less than 5% in 12 hours. Other investigators have used a chemical compound called ethephon to reduce the stripping force of fruitlet from the bunch.

Suryanto and Bardaie (1996) had reported that brushing 4-gram ethephon of 20-30 % concentration on cut bunch/spikelet stalk would hasten the fruitlet abscission and reduce the stripping force from about 300newtons to less than 20newtons after storing the ffB/spikelet for 24hours. Another study also reported by Suryanto and Bardaie (1996)showed that the application of ethephon would not affect the development of ffA.
The main objectives of this study are to develop an improved low-cost motorized oil palm fruit stripper and to determine its performance.

3. MATERIALS AND METHODS

3.1 Description of the Improved Design

The designed stripper consists of a prime mover, gear systems, frame, stripping unit, stripping unit housing and outlets for both stripped fruitlets and empty fruit bunches or spikelets.The frame

is made of a45mmx45mmx45mm angle iron which holds the whole system in a strong and rigid position. The stripping unit housing is cylindrical by shape with a dimension of 580mm diameter and 465mm height and is vertically erected on a frame which serves as a support. The cylinder has a perforated bottom screen through which stripped fruitlets pass to the fruitlets outlet. The housing wall is made of gauge 2.0mm galvanized sheet while the bottom is made of a network of10mm mild steel rods arranged in a 50mmx50mm squared mesh. Four bunch beaters are inclined against the inside wall of the cylinder.

A rotor assembly made of paddles is attached to a shaft, 10mm away from shaft tip; the rotor assembly is driven by a gear system which is powered by a 5.5 hp water cooled diesel engine. This rotor assembly passes from bottom of the cylinder to its middle along the centre of the cylinder.The fruitlets outlet is made of rods of 3mm diameter which are networked to 20mmx20mm squared holes to form sieve (mesh) and runs from the rear end of the bottom of the cylinder to the front at an inclined angle for easy rolling of the fruitlets into a collector. The sieve fruitlet outlet is for filters the fruitlets bras (small chaff) from the fruitlets. An outlet is also provided for the bunch/spikelet andthis is an opening on the side of the cylinder that is covered by a guard.These improvements made on the existing strippers use the principle of impact to remove the fruitlets from the bunch. Figures 1-3 give the detailed description of the low-cost oil palm bunch stripper.

3.2 Principle of Operation of the Improved Stripper

The stripper is operated by a5.5 hp water cooled diesel engine.
The sterilized bunches are fed into the machine through the opening into the stripping unit. As the rotor assembly rotates, the spikelets, quaterised bunches or whole bunches rotate with it and hit against the beaters. The hitting of the materials against the beaters causes an impact on the material and this impact loosens and detaches the fruitlets from the bunch. The loosened fruitlets pass through the sieve mesh at the bottom of the cylinder to its outlet and then pass through the fruitlet outlet screen where the chaff are filtered out and clean fruits are collected. The bunch guard is removed for the empty bunch to be let out through its own outlet.

3.2 Test Methodology

A preliminary test was carried out on the developed motorized oil palm fruit bunch stripper at 1200rpm using 7.5hp as power source and sterilized oil pam fruit bunches as testing materials to ascertain its performance .The procedure is as follows; a freshly harvested palm fruit bunches were stored for 36hrs under a closed system to allow for easy loosening of fruitlets. Each bunch was weighed out in three replications of a known quantity and each weighed bunch was fed into the stripper. The various weights of samples obtained during the evaluation were recorded and the recorded data were collated and analyzed.
The test parameters for stripping machines given bySuryanto and Bardaie(1996) were used to determine the performance of the stripper from data collated during the preliminary test as shown below;

a. Strippability (%), S_A: This determines how easy the stripper is able to remove or strip fruitlets from the bunch and is expressed as:

$$S_A = \frac{N_S}{N_T} x100\,(\%) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (30)$$

$$\text{And } N_T = Ns + N_u \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (31)$$

Where,

N_S = Number of stripped Fruitlets
N_U = Number of Unstripped Fruitlets
N_T = Total number of Fruitlets in the bunch

b. Clean Stripped Fruit Recovery (%), C_R: This determines the percentage by weight of clean stripped fruitlets received at the fruitlet outlet and is expressed as:

$$C_R = \frac{M_B}{M_D} x100\,(\%) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (32)$$

Where,
M_B= Weight of stripped fruitlets obtained at the fruitlet outlet
M_D = Total weight of fruitlets contained in each bunch

c. Input Capacity (kg/hr), I_C:- The weight of whole bunch including processing loss, passing through the stripper per unit time and is expressed as.

$$I_C = \frac{M_A}{T} \text{ (kg/hr)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (33)$$

Where,

M_A = Total weight of bunches fed into the stripper
T= Time taken to stripe the bunch of oil palm fruits

d. Output capacity (kg/hr), O_C:- this determines the weight of fruitletsreceived at theoutlet per unit time and expressed as:

$$O_C = \frac{M_B}{T} \text{ (kg/hr)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (34)$$

Where,
M_B and T as defined above.

4. RESULTS AND DISCUSSION

The prototype oil palm fruit stripper was designed and fabricated, the detailed isometric, orthographic, exploded and part drawings of the stripper are shown in figures 1-3. The result of the preliminary test carried out on the stripper using oil palm fruit bunches is given in the table 1. The results showed that the stripper has strip ability between 96.75% and 99.56%. This means that the stripper is effectively stripping the fruitlets from the bunches. Also, its clean fruit

recovery is between 90.91% and 99.73% which showed that very few or none of the fruitlets is lost during the stripping operation.

From the same table, the feed rate of the stripper ranges between 324.75kg/hr and 418.48kg/hr while its output capacity ranges between 231.66kg/hr and 323.12kg/hr. These results showed that the stripper will be able to handle up to two tonnes of oil palm fruit bunches in an 8hr/day operation which makes it suitable for the small-medium scale oil palm fruit processing industries.

6. CONCLUSION AND RECOMMENDATION

An improved design of a prototype oil palm fruit bunch stripper was made incorporating the salient features from the existing available strippers in Nigeria.

The low-cost improved oil palm fruit bunch stripper was then fabricated and preliminary test was carried out on it to ascertain its performance. Results from the test indicated a satisfactory performance of the stripper.

It is recommended that further work should be carried out on the stripper through a comprehensive performance evaluation to determine the effects of bunch harvesting period, bunch ripeness and bunch sterilization time on the performance of the stripper and on the quantity and quality of the palm oil obtained after extraction.

REFERENCES

Akande, F. B. (2001).Design and Construction of cassava washing machine. An Unpublished Bachelor in Engineering project, Department of Agriculture Engineering, Fed. Univ. Tech., Minna, Nigeria.

Bureau of Energy Efficiency (2004).Energy Efficiency Guide Book. (BEE), Government of India. Chapter 5, Pp 93-112.

CIAE (1987). 100 Bankable post-harvest Equipment developed India. Published by Central Institute of Agric. Engineering, Bhopal, India.

FAO (2001).Small Scale Palm Oil Processing in Africa .FAO Agricultural Bulletin 148. Goggle Search.

Gebr Stork (1960).Bunch stripping and stripping machines.Stork palm oil Review, Vol. 1 No 4 Oct. Pub. Gebr Stock &Co'sApparatenfabrick N.V. Amsterdam.

Khurmi, R.S and Gupta, J.K (2005).A Textbook of Machine Design (S.I. Units).Fourteenth edition. Published by Eurasia Publishing House (PVT) Ltd, Ram Nagar, New Delhi- 110055.

Obiakor S.I. (1998).Improvement of the prototype NCAM oil palm fruit processing system.Agricmech (1) 1; 32 –35.

Olaomi, J. (2008). Design and Construction of a Motorized Groundnut oil Expelling Machine" B. Eng Thesis, Department of Mechanical Engineering, University of Ilorin, Nigeria

Suryanto, H. and Bardaie, Z. (1996).Design parameters for stripping fresh oil palm fruitlets. AMA, 27 (3); 51-56.

Table 1: Preliminary Performance Evaluation Test onthe Bunch Stripper

S/N	Total Weight of bunches; $M_{A(kg)}$	Total number of fruitlets in each bunch; N_T	Number of fruitlets stripped from each bunch; N_S	Number of unstrapped Fruitlets; N_u	weight of fruitlets removed from each bunch; M_B(kg)	weight of empty bunch; M_C(kg)	Weight of the whole fruitlets in each bunch; M_D(kg)	time taken to stripe;$T_{1(sec)}$	Strippability; S_E(%)	Output Capacity; Oc (kg/hr)	Input Capacity; I_C((kg/hr)	Clean Fruit Recovery; C_R(%)
1	3.39	154	149	5	2.60	0.49	2.86	37	96.75	252.97	329.84	90.91
2	4.33	330	324	6	3.35	0.78	3.50	48	98.18	251.25	324.75	95.71
3	7.09	579	565	14	4.62	2.20	4.87	61	97.58	272.66	418.43	94.87
4	14.38	1133	1126	7	9.12	4.50	9.68	139	99.38	236.20	372.43	94.21
5	5.85	369	363	6	3.91	1.85	3.95	52	98.37	270.69	405.00	98.98
6	8.81	962	956	6	6.20	2.62	6.15	88	99.38	246.27	360.41	97.89
7	4.70	339	337	2	3.68	0.82	3.69	41	99.41	323.12	412.68	99.73
8	6.77	501	490	11	4.27	2.00	4.59	63	97.80	244.00	386.86	93.03
9	9.70	993	979	12	6.28	3.10	6.49	98	98.59	230.69	356.33	96.74
10	7.83	623	618	5	5.24	2.35	5.40	71	99.20	265.69	397.01	97.04
11	15.32	1141	1129	13	9.91	5.30	9.99	154	98.94	231.66	358.13	99.20
12	8.36	915	911	4	5.79	2.50	5.82	83	99.56	251.13	362.60	99.48
13	4.85	346	341	5	3.83	0.86	3.96	50	98.55	275.76	349.20	96.72
14	5.45	350	345	5	4.26	0.92	4.48	56	98.57	273.86	350.36	95.09
15	3.90	174	171	3	3.23	0.51	3.33	40	98.28	290.70	351.00	97.00

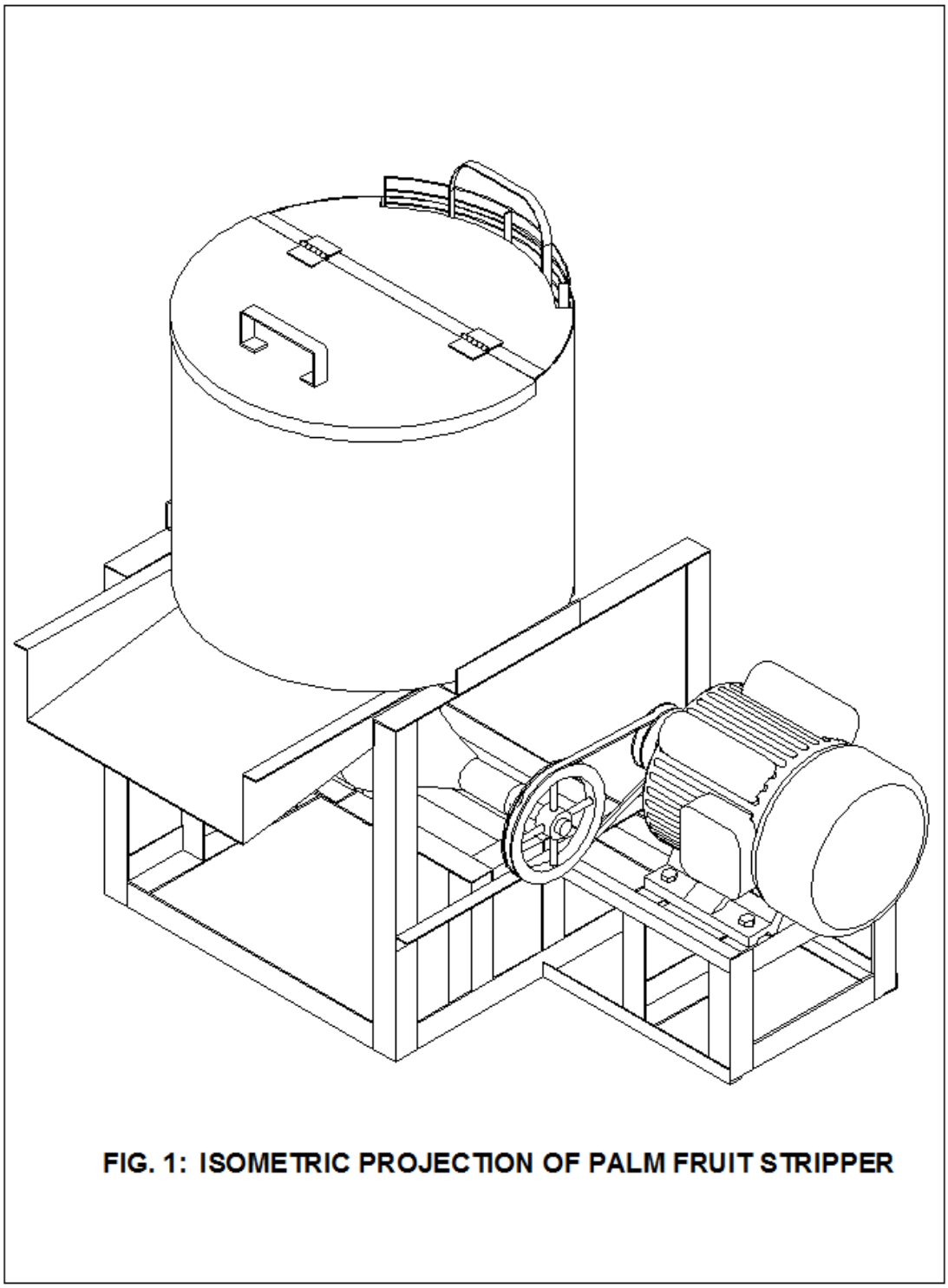


FIG. 1: ISOMETRIC PROJECTION OF PALM FRUIT STRIPPER

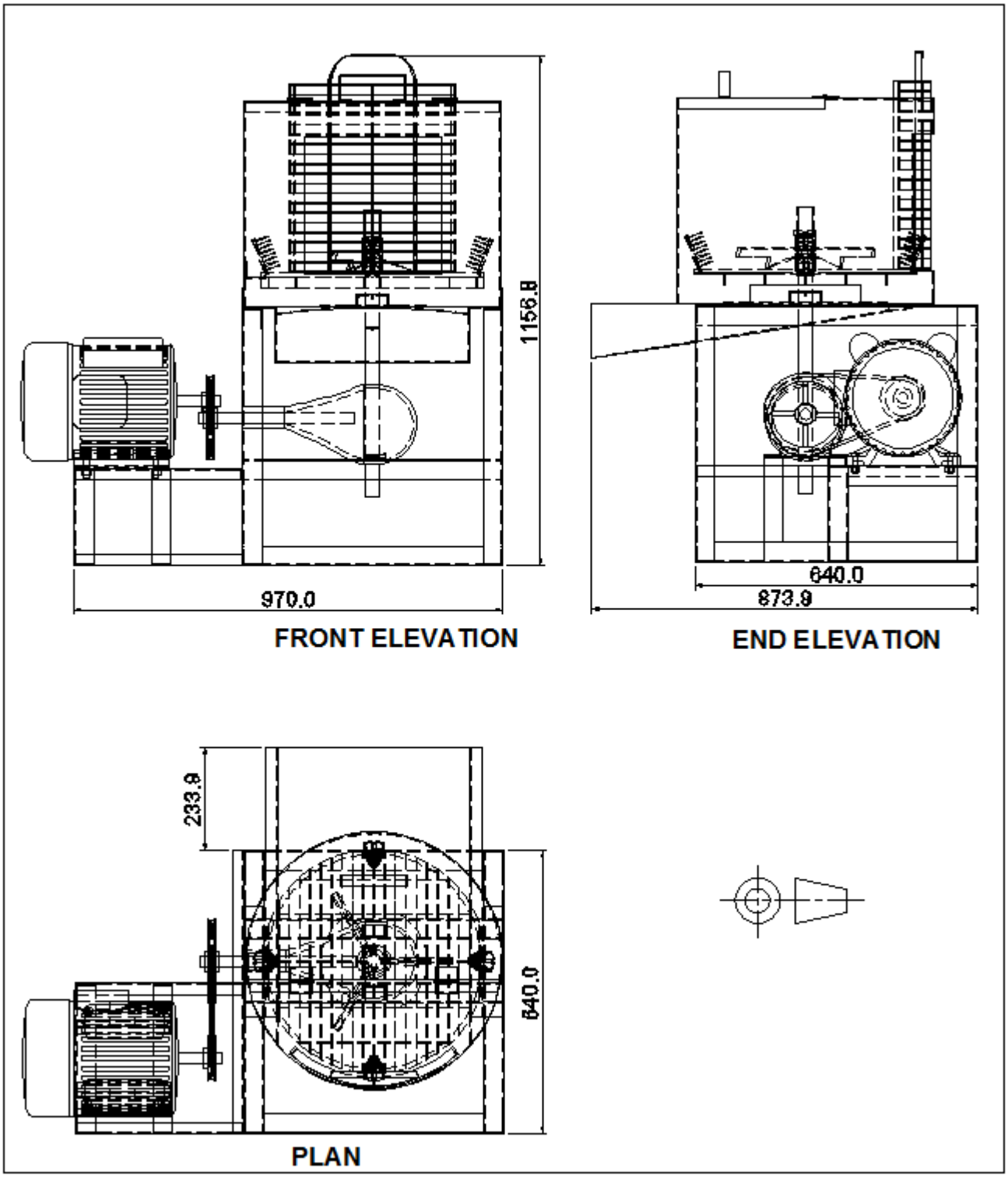
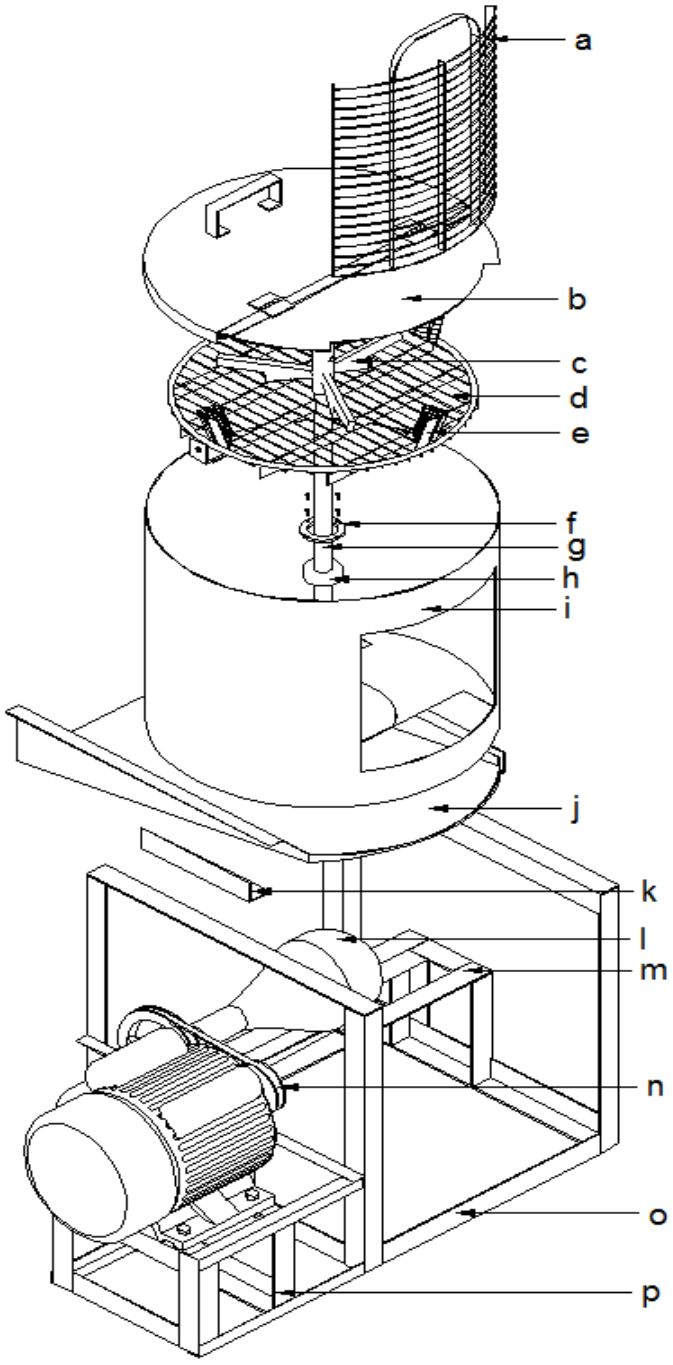


FIG. 2: ORTHOGRAPHIC PROJECTION OF PALM FRUIT STRIPPER



List of Part

p Motor seat
o Frame
n Belt
m Gear seat
l Gear system
k Outlet seat
j Fruitlets Outlets
i Stripping unit housing
h Bearing
g Main shaft
f Bearing seal
e Bunch beater
d Fruitlet screen
c Rotor assembly
b Cover
a Bunch guard

FIG. 3: EXPLODED VIEW OF PALM FRUIT STRIPPER

EFFECT OF PROCESSING METHODS ON THE PHYSICO-CHEMICAL PROPERTIES OF THE PALM OIL OBTAINED FROM OIL PALM FRUIT.

Bolarin F. M[1]. And Obiakor,S. I.[2]

National Center for Agricultural Mechanization (NCAM)P.M.B.1525 Ilorin, Kwara State.
talk2fade@yahoo.com; siobiakor4ever@yahoo.com

ABSTRACT

The physico-chemical properties of palm oil produced from two varieties (*tenera and dura*) of oil palm fruits using three different methodswere determined using the standard procedure. The properties determined were Iodine values, Saponification value, acid values, peroxide value and the free fatty acids value. The three processing methods are method A oil extracted from digested spikelets cut from sterilized bunch (wet extraction from spikelets only), method B oil extracted from digested fruitlets from sterilized bunch with water (wet extraction from fruitlet using centrifuge), method C oil extracted from sterilized and digested fruitlets with water(fruitlet sterilization with water. The two varieties of the palm fruit studied are tenera and dura.Iodinevaluesobtained for tenera variety were 43.0, 45.1 and 44.0, repectively for the three processing methods A,B and C. For dura the iondine values were 45.2, 42.0 and 43.0, respectively for processing methods A,B, and C.For the three methods, acid values were 3.93, 4.20, 4.40and4.32, 4.38, 4.48, for tenera and dura, respectively. Saponification value for tenera variety was 201.1, 200.1 and 201.5,while dura variety had values of 209.1, 201.2 and 201.4. Peroxide value for tenera variety was 4.31,4.42 and 4.50 while dura variety has values of 4.45, 4.55 and 4.48.The free fatty acid for tenera variety was $2.23x10^{-1}$, $2.38x10^{-1}$ and $2.38x10^{-1}$while dura variety has values of $2.32x10^{-1}$, $2.28x10^{-1}$ and $2.54x10^{-1}$.The results showed that processing methods affect the oil physico-chemical properties from each of the varieties studied and oil obtained from all the processing methods was good for both domestic and industrial purposes for both tenera and dura varieties.

Keywords: Physico-chemical properties, palm oil, processing methods.

1. INTRODUCTION

The oil palm fruit (Elaeisguineensis) has a central woody stalk to which clusters of spikelets bearing the fruit are attached. The palm fruit is a drupe with a fleshy outer layer called the mesocarp and a hard core called the nut. Two types of oil are obtained from the palm fruits which are the mesocarp oil (palm oil) and the endocarp oil (kernel oil). Oil palm fruit is a primary source of oil. Its percentage oil content is 45-50% (Chakroverty 1988). It contains carotene aids (corallines and xanthophylls'). The carotenoids content shows it is a good source of vitamin A. Palm fruit has about 3.0-5.0% of free fatty acid in the form of palmitic acid. Palm oil is an important agricultural product used for soup and margarines in many countries of the world. It is also used in the manufacturing of soap and cosmetics. Palm kernel oil is similar to coconut oil in its chemical composition and is used in manufacturing high quality toilet soaps, bakery coatings and sugar confectioner.(Babatunde, et al, 1986).The extraction of the oil from the oil palm fruit involves five different stages, namely sterilization. stripping, digestion, extraction of the oil and clarification.These operations are carried out in both small and large scales, the difference being in the sequences and equipment used.Oil extraction is a complex process, carried out by large mill that may process up to 60 tons of fruits per hour, or by small scale mills in rural villages that

produce only about 1 ton of oil in an 8 hours shift. Oil extraction from fruit follows the same basic steps in either case.

(1) Steam sterilization of bunches (inactivates lipase enzymes and kill microorganisms that produce free fatty acids, reducing oil quality.)
(2) Stripping fruit from bunches
(3) Digestion and heating of the digested mash.
(4) Oil extraction from macerated fruit (hydraulic press)
(5) Palm oil clarification

The method below is practiced by peasant women and small processors using mortars. The palm fruit are cooked in a pot and the cooked fruits were pound in a wooden mortar. The mash is then squeezed either by hand or any other method which will squeeze the oil out of the mash.The extract processing details depend on the kind of equipment to be used. Typical processing steps are as follows:

(1) Transportation of the harvested bunches to the mill with minimum bruising for processing within 24 hours.
(2) Sterilize/Cook the bunches with stem under pressure. The sterilization destroys the enzymes that cause the oil to ferment.
(3) Stripping the fruit from the bunches. This will likely be done with a mechanical bunch stripper.
(4) Process the individual fruit lets in a digester that releases the oil.
(5) Press the oil out of the digested fruit in a mechanical screw press.
(6) Remove water, dust, fibers from the oil by filtering and boiling and/ or using a centrifuge (Vogel, Jeffrey H.2002).

Another method is as follows:-

Harvesting: The FFB are sterilized for 60 minutes. In a harvested sterilizer.
Striping: Sterilized bunches are stripped in a rotary drum stripper to separate the fruits from the Bunches.
Digestion: The loose fruits are converted to semi solid pulp in the digester.
Processing: The digested mash is subjected to mechanical processing while hydraulic press is employed in small mills; a continuous screw press is used in larger mills.
Clarification: The oil water mixture from the press is separated into oil and water in a clarifier.

The objective of this study is to compare oil extracted using three different methods indicated in Figure 1 based on some quality parameters.

2. MATERIALS AND METHODS:

The palm fruit was obtained from NCAM and Eleyin Village in Isin Local Government Area of Kwara State.The process flow chart for the production of the palm oil by the three different processing methods are shown in figure 1.For the determination of the nutritional and functional properties of Palm oil, analysis was carried out using A.O.A.C (2000) methods. The following oil quality parameters were determined: - Carbohydrate content, Moisture content, Ash content, Protein content, Free fatty acid value, Saponification value, Iodine value and Peroxide value.

2.1. Free Fatty Acid

50 ml of mixture of diethyl ether and 95% ethanol was put into a conical flask.1 ml phenolphthalein indication was added to neutralize the mixture with a few drop of 0. Ml NaOH. 2.0g of sample was put into the neutralized mixture.0.1ml NaOH was titrated with the mixture until a persistency pink colour is obtained. (A.O.A.C, 2000)

2.2. Iodine Value

25ml of Dams Bromide solution was shaken with 2.0g of sample;it was dissolve in 10 cm^3 of Chloroforms in a conical flask. The mixture was left in the dark for 30 minutes. 10 cm^3 of 10% potassium iodide solution was added to the mixture and it was shaken thoroughly. The conical flask was washed with 75 ml of distilled water.1 ml of starch indicator was added.The solution was titrated against 0.1 ml $Na_2S_2O_3$until the end point is reached. A blank was prepared simultaneously. (A.O.A.C, 2000).

2.3. Saponification Value

2.0g of sample was put into a conical flask,25 ml of alcoholic potassium hydrate was pipetted into the flask which was fitted with a reflux condenser on a hot water bath for 60 minute. 1 ml of Phenolphthalein indication was added. The hot solution was titrated with 0.5m Hcl. A blank was prepared into another flask and simultaneously. (A.O.A.C, 2000)

2.4. Peroxide Value

This work was carried out in subdue light. 2.0g of sample was put into a conical flask with 2 g of powdered potassium iodide. 20 ml of the solution glacial acetic acid/Chloroform (2:1%) was added. The mixture was heated for 60 seconds. 20 ml of 5% potassium iodide solution was added to the heated mixture. 25 ml of distilled water was added to rinse the mouth of the conical flask. 1 ml of starch indication was added. The solution was titrated with 0.0002m $Na_2S_20_3$ until the end pointwas reached. (A.O.A.C, 2000)

3. RESULTS AND DISCUSSION

The result obtained for the Physcio- chemical properties are shown in table 1.The peroxide values usually indicates the rancidity level of the oil. This falls within the range (2.7 - 7.4 mg/KOH/g) reported for some locally processed Nigerian Palm oils (Aletor et. al, 1990).The tenera variety has a lower value of 4.31 when processing method A was used, the highest peroxide value of 4.55 was obtained when method B was used with the Dura variety.Peroxide value correlates with the extent to which oxidative rancidity has taken place in oil, and thus a measure of the shelf life of the vegetable oil. With the low peroxide value obtained it shows that the oil is not highly oxidized and therefore will begenerally acceptable for the absence of odor and flavor in its content (Pearson, 1981). Pearson reported that oil become rancid when peroxide values range from 20.0 to 40.0 mglg oil while Ojeh showed oils with high peroxide value to be unstable.

The highest acid value of 4.48 was obtained from the Dura variety using the processing method C.The acid value of oil may be used as a measure of quality.The acid value is a measure of total acidity of the system, which may involve contributions from all the constituent fatty acids that make up the glyceride molecule. However, the acid value of the oil must not be too high, as this denotes an excessively high content of free fatty acids, which causes the oil to turn sour. Discoloration may also occur. (TIS, 2000).

The highest iodine value of 45.2 was obtained by the Dura variety using the processing Method A.This shows that the palm oil contains some degree of unsaturation. The values obtained falls within the range obtained by TIS which means it does not dry easily. With an iodine value of 43 - 58, palm oil is nondrying oil, which means that it does not dry significantly on contact with atmospheric oxygenn. (TIS,2000).

The highest saponification valuewas obtained by the Dura variety using the processing method A.The high saponification value indicates that the oil contains a high degree of triglycerides and low molecular weight fatty acids. These value indicate that the samples contain a large number of fatty acids of low molecular weight and hence useful in soap industries. (Onyeike and Oguike, 2003)

The highest free fatty acid value of $2.54x10^{-1}$was obtained for the dura variety using the processing method C. Low free fatty acid content shows that the oil would not easily go rancid when properly stored. Both acid value and free fatty acid value are very important in determining the use of oil for industrial or edible purposes.

The experiment on Free Fatty Acid shows significant differences for both variety and methods at 1% level of significance. Free Fatty Acid was higher in Dura variety (2.4078) compare to Tenera variety (2.2932). There is also a Method effect implying that at least one of the methods is statistically differently from the other methods. We therefore reject the null hypothesis of equal mean treatment effect between methods. Further investigation using Duncan multiple comparisons revealed that method A recorded the highest mean value of about 2.3997, compare to all the other methods. There also seem to be a combine effect of Variety and Methods since the interaction between the two treatment effects is significant at 1% level.

The experiment on Peroxide value shows significant differences for both variety and methods at 1% level of significance. Tenera variety yields mean Peroxide value of about4.4933 which was statistically higher than the mean Peroxide value of 4.4433 recorded by Dura variety. There is also a Method effect implying that at least one of the methods is statistically differently from the other methods. We therefore reject the null hypothesis of equal mean treatment effect between methods. Further investigation using Duncan multiple comparisons revealed that method C is significantly higher compare to all the other methods. There also seem to be a combine effect of Variety and Methods since the interaction between the two treatment effects is significant at 1% level.

The experiment on Sap value shows significant differences for both variety and methods at 1% level of significance. Tenera variety yields mean Sap value of 203.27 which was significantly higher than the mean Sap value of 4.1589 recorded by Dura variety. There is also a Method effect implying that at least one of the methods is statistically differently from the other methods. We therefore reject the null hypothesis of equal mean treatment effect between bothvariety and methods. Further investigation using Duncan multiple comparisons revealed that each method considered are significantly different from the other. However, Method A recorded the highest mean Sap value of 209.01. There also seem to be a combine effect of Variety and Methods since the interaction between the two treatment effects is significant at 1%.

The experiment on Acid value shows significant differences for both variety and methods at 1% level of significance. Tenera variety has mean Acid value of 4.3442 which is significantly higher than the mean Acid value of 4.1589 recorded by Dura variety. Methods on the other hand were also significant implying that at least one of the methods is statistically differently from the other methods. We therefore reject the null hypothesis of equal mean treatment effect between treatments level for both variety and methods. Further investigation using Duncan multiple

comparisons revealed that each method considered are significantly different from the other. However, Method C recorded the highest mean Acid value of 4.4117.

The experiment on iodine value shows significant differences for both variety and methods at 1% level of significance.Dura variety has mean Iodine value of44.04 which is statistically higher than the mean iodine value of 43.82 recorded by the tenera type. Method on the other hand is also significant implying that at least one of the methods behaves differently from the other methods. We therefore reject the null hypothesis of equal mean treatment effect between the levels treatment, for both variety and methods. Further investigation using Duncan multiple comparisons revealed that each method considered are significantly different from the other. However, Method B recorded the highest mean iodine value of about 44.5500 The interaction between variety and methods was also statistically significant at 1% level implying that there is a combine effect of the two treatment effect on Iodine value.

4. CONCLUSION

The proximate analysis of the Palm oil produced from three different methods shows that the tenera variety has a higher value for the crude fat,ash content and protein content with low moisture content,while dura variety has a higher fibre content and carbohydrate content.The physico-chemical properties shows that tenera has a low peroxide value,low acid value,while dura variety has a high iodine value, and saponification value which makes it a good raw material for the production of soap.

Method A and C are the best processing method for the processing of oil palm fruit to palm oil which is recommended for both domestic and industrial purpose, but method A is the very best judging from the results obtained from both the proximate and physico-chemical analysis.

REFERENCES

Aletor, V. A; Ikhena, A. F. and Egharevba, V. (1990):"The quality of some locally processed Nigerian. Palm oils: An estimation of some critical processing variables", Food chemistry, 36, 311-317.

Atchley, A.A. 1984. Nutritional value of palms.*Principes* 28(3):138-143

BabatundeAjibola O.O. Ige, M.T.C.(1986):- Chopping as an alternative to fruit shipping in low cost palm oil processing in proceeding of the annual conference of the Nigerian Society of Agricultural Engineers volume 10, 1986.

Cottrell, R.C. (1991):- "Introduction: - Nutritional aspects of palm oil" the American Journal clinical nutrition. 53 (4 suppl) 9895 – 10095.

Dr. A. Chokraverty (1988): post –harvest technology of Cereals, pulses and oil seeds. Revised edition pp. 261 – 21.

Eseigbe, R. A. and Etuk E. (1981):- Status of the Nigerian palm oil industry-paper presented at the First African small scale palm processing workshop held at NIFOR, Benin City, Nigeria, and October, 1981. Pp. 12 – 16.

Essiamah, K. Sam (1983):- Sapping of oil palm (Elaeis) guineensis, Jacq) in the Rain fall Region of West Africa I plant research and development. A Biannual collection contribution concerning development through Research.Volume 38 pp. 36-40

Esuoso, K.O and Odetokun, S.M. (1997): Proximate chemical composition and possible industrialutilization of Bliphiasapida and seed oils, R.V. Italian Sostanze Grasse. 72 (7)

Jp Lifestyle Alternative medicine online (2005): The health benefit of palm oil

Mensink, R.P. Katan, M.B. (1992). Effect of dietary Fatty acids on serum lipids and lipoproteins.A meta-analysis of 27 trials "ArterioselerThromb 12 (8) 911.

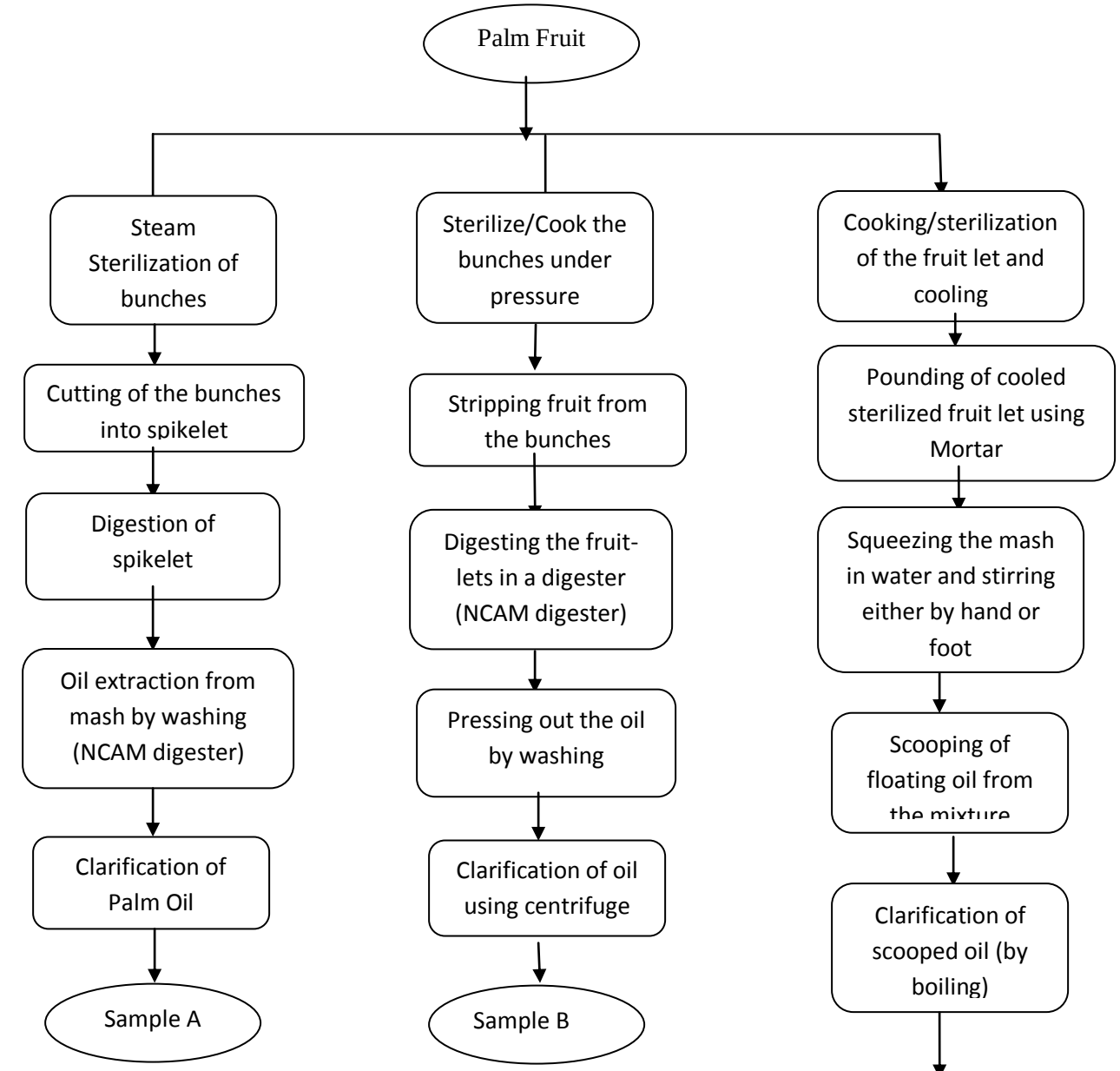
Onyeike N. Eugene and Oguike.U.Julliana (2003): Influence of heat processing methods on the nutrient composition and lipid characterization of groundnut oil seed in Biochemistry NSEB Vol. 15 Num. 1 Pp 34-43.

Pearson, D. (1981); Chemical Analysis of Foods, 7th edn. AVI Publishers, Wets Port

Transport Information Service (TIS):-Cargo Loss Prevention Information from Germany marine insurers

UK Food labeling Regulations (S11984, No. 1305).

US federal food, Greg & Cosmetic Act. 21 (FR. 101 – 25 as amended in Federal Register July 19, 1990. Volume 55 No/ 139 pg. 29472.



Method A
(Oil extracted from digested Spikelets cut from sterilized Bunch)
(wet Extraction from spikelet only)

Method B
(Oil extracted from digested fruitlets stripped from sterilized, Bunch with H2O).
(wet extraction from fruitlets using centrifuge)

Method C: (Oil Extracted from sterilized a digested fruitlets with water).

(fruitlet sterilization with water

Fig. 1: Process flowchart for the Processing of palm Fruit to Palm Oil by using three different Methods.

Table 1:Physico-chemical properties of palm oil Samples

	O		**P**		**Q**		**R**		**S**	
Methods	1	2	1	2	1	2	1	2	1	2
A	43.0	45.2	3.93	4.32	201.1	209.1	4.31	4.45	$2.23x10^{-1}$	$2.32x10^{-1}$
B	45.1	42.0	4.20	4.38	200.1	201.2	4.42	4.55	$2.38x10^{-1}$	$2.28x10^{-1}$
C	44.0	43.0	4.4	4.48	201.5	201.4	4.50	4.48	$2.38x10^{-1}$	$2.54x10^{-1}$

O = Iodine Value, P = AcidValue, Q = SaponificationValue, R = PeroxideValue, S = Free Fatty Acid, 1 = Tenera, 2 = Dura

Table 2:- Effect of methods of processing on free fatty acid of produced palm oil

			Subset		
	METHODS	N	1	2	3
Duncan[a]	METHOD C	6	2.2650		
	METHOD B	6		2.3767	
	METHOD A	6			2.3997
	Sig.		1.000	1.000	1.000

Table 3:- Effect of methods of processing on peroxide value produced from palm oil

			Subset		
	METHODS	N	1	2	3
Duncan[a]	METHOD A	6	4.4267		
	METHOD B	6		4.4600	
	METHOD C	6			4.5417
	Sig.		1.000	1.000	1.000

Table 4:- Effect of methods of processing on saponificationvalue of produced palm oil.

			Subset		
	METHODS	N	1	2	3
Duncan[a]	METHOD B	6	2.0077E2		
	METHOD A	6		2.0112E2	
	METHOD C	6			2.0272E2
	Sig.		1.000	1.000	1.000

Table 5:- Effect of methods of processing on acid value of produced palm oil.

			Subset		
	METHODS	N	1	2	3
Duncan[a]	METHOD A	6	4.1517		
	METHOD B	6		4.2050	
	METHOD C	6			4.4117
	Sig.		1.000	1.000	1.000

Table 6:-Effect of methods of processing on iodine value of produceds palm oil.

			1	2	3
	METHODS	N			
Duncan[a]	METHOD A	6	43.0500		
	METHOD C	6		43.5333	
	METHOD B	6			44.5500
	Sig.		1.000	1.000	1.000

DESIGN AND CONSTRUCTION OF EGG INCUBATORWITH FAULT ANALYSIS ALERT CONTROL SYSTEM USING SHORT MESSAGE SERVICE (SMS) FOR AGRICULTURAL FARMSTEAD

Uzoigwe, L.O.[1],Mbajiorgu, C.C.[2]and Maduakolam, S.C.[3]

[1, 3]Faculty of Engineering, Department of Agricultural Engineering, Imo State University, Owerri.*luzoigwe@yahoo.com, buknella@yahoo.ca*

[2]Faculty of Engineering, Department of Agricultural and Bioresources Engineering, University of Nigeria, Nsukka.*Const.C.mbajiorgu@talk21.com*

ABSTRACT

The egg incubator system with temperature sensor can measure the state of the incubator and automatically change to the suitable condition for the egg. The health of the egg is very important for the development of embryo. In this paper, the light heater is used to give the suitable temperature to the egg by using the controlling fan. The status condition in the incubator system will appear on the liquid crystal display (LCD) screen. To make sure all part of egg was heated by lamp, direct current (DC) motor was used to rotate iron rod at the bottom side and automatically change the position of egg. The entire element is controlled using programmable integrated circuit (PIC) – a type of microcontroller that can process a data from sensor and will execute the control element to change the condition of the incubator system. The heater is interfaced with the controller through the optocoupler. The optocoupler isolates the microcontroller from the alternating current (AC) power, thereby preventing any possible flow back of the AC into the control circuit. The software intelligent agent was embedded into 8051 family of micro controllers, emulating theattention commands of the receiver-transmitter modem (mobile cell phone) using window HyperTerminal and microcontroller and thus translateattention commands to assembly language,having machine cycle of 1.085s,R=10K,C=10µf, t=2.17µs,transistor collector current,Ic=800mA and emitter forward current gain,h_{fe} gives 200.The SMS mobile cell phone using Atmel microcontroller (AT89C51) inthe prototype self diagnostic systems, will not only control the temperature of an incubator but also detect and analyze faults in the system.

Keywords: Optocoupler, Programmable Integrated Circuit (PIC), Receiver-transmitter modem and Window HyperTerminal

1. Introduction

The ancient Egyptians and Chinese both devised incubators to hatch chicks from eggs without the mother hen sitting on the eggs. This enabled hens to continue laying eggs. The Egyptian incubators were large rooms heated by fires; attendants turned the eggs at regular intervals so they would warm evenly. Some Chinese incubators were warmed by fire, others by rotting manure. The Italian inventor, Jean Baptiste Porta drew on the ancient Egyptians designs to build his 1588 egg incubator, but was forced to abandon his work by the inquisition. Dutch inventor, Cornelius Drebbel also invented an incubator to hatch eggs.

Knowledge about egg incubation was revived and introduced throughout Europe by the inventive Frenchman Rene-Antoine Ferchault de Reaumur (1683-1757) around 1750. Reaumur's device was by a wood stove; temperature was controlled by a thermometer, also invented by Reaumur, which gave rise to the temperature scale named after the inventor. The success of Reaumur's

incubator and Louis (1710) enjoyed helping the chicks hatch andboosted commercial production of foodstuffs at the beginning of the industrial era.After Reaumur's death, the incubator was further developed by Abbe Jean-Antoine Nollet (1700-1770) and later by Abbe Copineau, who used alcohol lamps as a source of heat (http://search.datasheetcatalog.net/key/LM35,http://Incubator%20Summary%20%20%20BookRags.com.htm).

Today's incubators are electrically heated and turn the eggs automatically. The large ones may hold up to 75,000 eggs.With the innovations associated therein,faults in the incubation system could be detected through the software intelligent agent (SIA), embedded into themicrocontroller (ATMEL89C51). From Barrand Feigenbaum, (1981); Rocks and Mazur,(1993) contributions the (SIA), monitors the fan that brings about good air circulation in the incubator, the heater which heats up the incubator, the sensor- analog to digital converter(ADC), that converts the analog temperature to digital value.When the agent detects fault(s), it uses the case based reasoning built into the controller to diagnose the cause of the fault and hence the possible solution can be predicted. Ram, (2008), worked on microcontroller that could send the cause of the fault and the possible solution to the liquid crystaldisplay (LCD) interfaced to it and at the same time copy the same information to the mobile number of the maintenance personnel, thus turning ON the buzzer alarm. Depending on the nature of the fault, Einar et al., (1997); Hunt, (1996); Trevor, (2000) and Datasheet Catalogue (2011) found out that the controller might decide to shut down the entire system irrespective of the case based reasoning.

For incubator bird chicks to survive, they demand a precise temperature of 91^{o}F. If the chicks must survive, the temperature must not vary more than one degree on either side of 91^{o}F. Scientists differ on the mechanism they think the bird uses to measure the temperature. Some think the bird's thermometer is in its beak while others believe the tongue can distinguish 91^{o}F and a few tenths of a percent above and below 91^{o}F. For the bird to keep the eggs at 91^{o}F, the male digs down into the nest and checks the temperature. On hot days, he may pile extra sand on top of the nest to shield it from the sun. He may even rearrange the entire pile of rotting leaves and grasses several times a day. Paul and Winfield(2002),on their research found out that in the cooler days, the male megapode (which means big feet) will push material off the top of the nest to permit more sunlight to penetrate the decaying organic material. Or, to keep the humidity at 99.5% around the eggs, he may dig conical holes toward the eggs to get more moisture deeper into the nest.

In view of high-tech associated with this work, thefollowing elements were considered:

Monitoring: The temperature of the incubator is monitored through the temperature sensor connected to microcontroller via analog to digital converter (ADC).

Control: The microcontroller uses the control program embedded into it to actuate the heater and air-circulation fan. Temperature is maintained within a defined limit by switching ON or OFF the heater.

Fault analysis and alert: Intelligence is built into the controller using rule based reasoning. In order to build the required intelligence into the controller, by simulating the components under normal and fault conditions using proteus professional. The analysis arising from the simulation was then translated into case-based reasoning program. The alert is in three levels: SMS alert,

buzzer alarm and liquid crystal display (LCD) .Each time a fault occurs, alert is sent to the mobile phone numbers of the maintenance personnel. The alert describes the nature of the fault and the possible solution. The same information sent to the maintenance personnel is also displayed on the liquid crystal display (LCD). Depending on the nature of the fault, the system might refuse to start or shut down if already in operation. Buzzer alarm, alerts the operators of the immediate faults, as shown in block diagram overview of Figure 1.

2. DESIGN METHODOLOGY AND SYSTEM ANALYSIS

The following were considered in this work:

1. The processes that would be involved and the necessary technology required.
2. The availability of materials/components required for implementation.

Clearly this work involves control, intelligent faults analysis, and full duplex serial communication processes.

The technology used in implementing SMS is that of Global System Mobile Communication (GSM) which entails the use of attention (AT) command to write to the memory of a mobile cell phone. AT command is a set of instructions made up of the American Standard Code for Information Interchange (ASCII) strings with predefined functions which every mobile cell phone should understand, depending on the phone manufacturer. Half duplex serial communication requires transmitter and receiver, transmitting and receiving at an agreed protocol, especially the baud rate.

Thus,it becomes obvious that Gate-Oriented design which involves equation-to-gate conversion, map simplification, output function synthesis and next-state function synthesis, flip-flops, state assignment and hazards cannot be used to implement this work. Even Read Only Memory (ROM) Centered Design where ROM is used to implement control process is not the most economical as ROM does not have serial communication capability. And it will certainly be cumbersome to build intelligence into ROM.

One possible way to implement this system is to use a computer, i.e. interface the system to a computer and then use high level language to develop the intelligent fault analysis program and serial communication program. The bottle neck with this method besides the cost is that the computer has to be on as long as the incubator is on. The microcontroller-based implementation was chosen due to the following reasons.

1. Since AT command is a string of ASCII characters, it can easily be emulated using microcontroller.
2. It supports a set of baud rates which are compatible with most mobile cell phones.
3. Microcontroller supports multi-level programming. In other words, its memory can be mapped into various sections. Each sub-routine can then be assigned a particular section of the memory, with one central programming calling each sub-routine when necessary. In this work for example, there are three major sub-routines: Intelligent, i.e. fault analysis, serial communication, and control subroutines.
4. Microcontroller also has interrupt capability, That is to say that it can suspend whatever action it’s executing whenever an events of higher priority occurs and attend to that event after which it goes back to what it was doing.

5. **Microcontroller** can run at external clock speed of 24MHz. With this, any fault can be detected within microseconds.

2.1. Structural Analysis and Design Method

The structure of design and implementation of self diagnostic intelligent incubator control system is that of a prototype that could be demonstrated in a laboratory.

It is an embedded system in the sense that the software controlling the system is embedded in the controller. The inputs to the system are the temperature signal from the sensor, signal from GSM modem transmitter/receiver and feedback from outputs actuators. (http://wataniya.yahoo.com/smshistory.html,2003;http://www.developershome.com/sms/, 2002).

Theoutputs devices include the buzzer alarm, liquid crystal display (LCD), fan and electric heater.

2.2. Design Method

Each section of the work is developed and tested before the final coupling. The glass used is Perspex glass, which was used for transparency. It can withstand a temperature of 100^{o}C, likewise the black casing, (Leo, 1995).

Features of MY-X7 Sagemphone series that make them suitable for emulation using microcontroller.

1. The serial port is compatible with transistor-transistor logic (TTL) levels. Thus there is no need for voltage level conversion between the phone and controller.
2. The serial transmit pin has dual function of transmitting data and charging of the phone.
3. A voltage of 5-7V and current of 300mA at transmit pin will cause the phone to start charging while the pin sees a voltage of 5V and current of about20mA as data.
4. The phone has its Attention Command (AT) for sending SMS enabled.
5. There are two modes of SMS: PDU and text modes. In text mode, one can easily write to the phone in American Standard Code of Information Interchange (ASCII) format.
6. The baud rate can be manually set.
7. It has USB-to-serial cable for connection to the computer. The cable, one can understand the AT command of the phone using Hyper Terminal program.
8. One can check the state of the battery using AT command.

2.3. Design of Case base reasoning sub routine for fault analysis

To be able to build intelligence required to actualize this work into the microcontroller, one must understand how relays, transistors, ADC, optocoupler, temperature sensor (LM35), diodes work under normal conditions. This is because failure of any of these components used in the circuit design directly affects the system.

2.4. Investigation of how LM35 and ADC0804 work under normal and abnormal conditions

Below is the screen shot of the schematics used to investigate how LM35 and ADC0804 work under normal and abnormal conditions. The software (Figure 2), used for simulation is proteus professional. The values of the components used are not arbitrary.

LM35 has a linear output with accuracy of 10mV/C. Its temperature range is from -55ºC to 150ºC. The temperature output is supplied to the input of the ADC0804 (VIN+). A voltmeter, V1 is also connected across the sensor output to measure the analog to digital converter (ADC), as shown in Table 1, forthe result of the simulation.

If ADC0804 has no output,then,there is no power to it. Else, the chip is bad since is most unlikely that the capacitor, C1 and resistor, R1 used in determining the clock value for the analog digital converter (ADC) will go bad (little or no power is dissipated on them). Likewise the investigation of how relay and optocoupler work under normal and abnormal conditions, is shown in Figure 3.

From Figure 1, the block diagram overview of this work, the optocoupler will isolate the microcontroller from the AC heater.J1 is the feedback to the micro controller.

2.5. Temperature interface to the microcontroller

Figure 4 shows how to interface the temperature sensor LM35 to the microcontroller AT89C51.

2.6. External Reset

Pin 9 (see Figure 4) is the RESET pin. It is an input and is active high (normally low). Upon applying a high pulse to this pin, the microcontroller will reset and terminate all activities. This is often referred to as a power on reset. In order for the RESET input to be effective, it must have a minimum of duration of 2 machines cycles. Interface of the Liquid Crystal Display (LCD) to the controller is shown in Figure 5,while interface of AC heater to the controller with feedback is shown in Figure 6.

The heater is interfaced to the controller through the optocoupler. The optocoupler isolates the microcontroller from the A.C. power, thereby preventing any possible flowback of the AC into the control circuit.

The DC fan requires 5V to function. The relay used here is 5V so that the power consumption will be reduced to the minimum.

The feedback loop sends a low to the controller each time the relay is in the off condition. This is visible by the light emitting diode (LED) indicator, D4. D4 requires at least 5mA to come on to the Buzzer Alarm (Figure 8)

2.7. The Power Supply

The block diagram of the power supply is shown in figure 9 while the shematic is shown in Figure 10.

2.8. System Design

The voltage charge in an RC circuit is given by:

$$Vc = V (1 - e^{-t/RC}) \quad (1)$$

Where RC = time constant

t = 2 machines cycles

So, V = Vcc = 5V

Vc = voltage across C2 which is usually less than Vcc because of discharging action of the capacitor.

Machine cycle = 1/value of crystal/12MHz

1/machine cycle = 11.0592 x 10^6 / 12 x 10^6 = 921.6 KHz

Machine cycle = 1/921.6 KHz = 1.085 sec

2machiunes = 2 x 1.085 = 2.17μs

From (1) Vc/V = 1 – e^-t/Rc (2)

e^-t/Rc = (1 – Vc/V) (3)

lne^-t/Rc = ln (1 – Vc/V) (4)

c = -t/R(1 – Vc/V) (5)

Let R = 10k, then c = 10μf, t = 2.17μs

2.9. Choice of the Optocoupler 4N35

This optocoupler is cheap and available.

Input LED forward voltage = 1.15 (typical).

Input LED forwards current = 10mA.

Now Vcc = 10mA (R1) + 1.15

Vcc = 5V

5-1.15/10 x 10^-3 = R1

R1 = 3.35 x 10^2/10 = 3.85 x 10^2

R1 = 385Ω.

Collector current of the optocoupler, Ic = 150mA, continuous.

Also Vcc = IcR2

5/150 x 10^-3.

R2 = 5 x 10^3/150

R2 = 33Ω

This is the minimum value of R2. This value can be increased and the device will still work perfectly especially when it is required to bias a transistor (in this case BC337) when the optocoupler is off. Thus, R2 can be taken and increased to a value that can bias the transistor.

2.10. Choice of 240V/10A Relay

The heater rating is 100w, 220V. But power = I x V.

100/220 = 0.45A.

Thus the relay meets the current and voltage requirement of the load (heater).

2.11. Choice of Transistor BC337

The resistance of relay coil = 400Ω (given).

Current I, through the coil = 12/400 = 30MA.

The transistor BC337 can handle this current very well (its h_{fe}= 200 typical).

Now when the optocoupler is off, from kickoff's voltage law:

$Vcc - I_bR_2 - Vbe = 0$ (6)

For silicon transistors, Vbe = 0.7V

$5 - 0.7 = I_bR_2$, $4.3 = I_bR_2$.

$$But I_b = \frac{I_c}{h_{fe}} \quad (7)$$

Where I_c = transistor collector current=800mA

And emitter forward current gain, hfe = 200

$I_b = 0.8/200 = 0.004A$

$R_2 = 4.3/I_b = 4.3/0.004$

R_2=1kΩ

2.12. Choice of the Freewheel Diode, 1N4001

The free wheel diode D1 protects the transistor from inductive click of the relay. The peak inverse voltage of 1N4001 = 50V, its forward current is 1ampere. These are well above 30mA and 12V.Thus Vcc = IR implies, R = 5/ (5 x 10^-3) = 1kΩ.

Based on the systems design, the component parts were assembled and tested for its reliability as shown in Figure 11.

2.13. System Specification

The digital ICs used in the design and implementation of microcontroller based self diagnostic incubator control system with fault analysis alert using short message service (SMS) are ADC0804 and AT89C51 microcontroller. The voltage requirement for both of them is +5V. This +5V is supplied to each of ICs from the power supply circuit with a 7805 regulator IC. For the 12V D.C relay that is used in the output interface, the voltage required to switch it, +12V and this is tapped from the unregulated voltage of the power supply. The alternative to this way is to connect another 12 volts regulator at the input of the unregulated voltage to get exactly 12 volts. 220AC/100watts electric bulb whose power is provided by the mains is used as incubator heater.

Other components used are BC337 (transistor), 4N35 (optocoupler), buzzer alarm, LM35 (temperature sensor).MY-X7 Sagem mobile phone (transmitter/receiver). Each of them requires +5V D.C to function. The step-down transformer that is used for the power supply is 240V A.C to 12V A.C with the current rating of 800mA. The system's main features are summarized in Table 5.

2.14. The Hardware Subsystems Design:

The hardware subsystem is made up of the input interface, the output interface, the feedback loops and the control system. The schematic block

Diagram of the hardware subsystem is shown in Figure 12 below.

2.15. Software Subsystem Testing

The software testing was divided into three major modules: the input, output and serial communication modules.

- **a)** The output module was first developed and tested to make sure that data are being displayed properly, and that the relays, fan, and heater were properly switched. The feedback loop was also tested and confirmed okay.
- **b)** The input module was developed to reading temperature value from LM35 through ADC0804.
- **c)** The serial communication protocol between the controller and the phone was developed and tested.
- **d)** Finally, the entire software was put together by way of integrating all the modules in a main control loop and tested for conformity with the main control algorithm.

The software is in three levels: The intelligent fault analysis subroutine, serial communication sub routine and temperature control sub routine.The Initialization Flow Charts are as shown Figures 13.

Sample codes for Initialization of The System

```
org  00h                    ;  Begin the program from origin

main

callinit_LCD                ; initialze the LCD

callinit_ports              ; Initialze the input/output ports of the controller

jmp end_                    ; end of initalization

init_lcd:mov a,#38h         ;  make LCD 5 x 7  matrix

callwr_instr                ; send instruction to LCD

mov a,#0ch                  ; display on, cursor off

callwr_instr                ; send instruction to LCD

mov a,#06h                  ; Increment cursor
```

```
callwr_instr                    ; send instruction to LCD
mov a,#01h                      ; clear display screen
callwr_instr                    ; send instruction to LCD
ret                             ; return to the main program
setb p3.6                       ; make p3.6 an input port
setb p0.1                       ; make p0.1 an input port
mov p1,#0ffh                    ; make p1 an input port
ret                             ;return to the main program
init_ports:                     end_: end
```

3. CONCLUSION

A standard prototype of the microcontroller based self diagnostic incubator control system with fault analysis alert using SMS and attention command(AT) was demonstrated. This approach can be applied to many other control/ monitoring systems.

The process of developing and embedding intelligent agents into 8051 family of microcontrollers was clearly shown. This will be of great help to systems developers.

TTLor CMOS ensures that the chips are compatible, if not appropriate drivers should be used.

Much loss is incurred whenever an incubator develops faults especially where the expatriate is not locally available. It is therefore necessary to build self diagnostic intelligent agents into such systems to aid maintenance personnel in fault analysis and management. This work shows the way to building such intelligent system.

REFERENCES

Ram, B (2008): Fundamentals of Microprocessors and Microcomputers, sixth edition DhanpatRai publication, pp 53-59.

Barr. A. and E.A. Feigenbaum, (1981):The handbook of Artificial Intelligence,Addison-Wesley, London.

Einar L. and T. N.Johnnneson, (1997): Christian Steinebach, intelligent diagnosis and maintenance management, in Wang.K. andPranevicius, H, Editors, Application of AI to production Engineering, Kaunas University of Technology Press, Technological, pp 199-235.

Hunt T. M-J, (1996): Condition Monitoring of Mechanical Hydraulic plant, Chapman & Hall, London.

Leo J. Scalon, (1995): IBM PC & XT ASSEMBLY LANGUAGE > (A Guide for Programmers), Brady Communication Company, p. 14.

MazidiM.A, and J.C. Mazidi(2000): The 8051 Microcontroller and Embedded Systems, Prentice-Hall, Inc. Pearson. Motorola semiconductor Technical data sheet, 4N35/D .

Paul H. and H. Winfield, (2002): The art of electronics, 2nd edition, Cambridge University Press UK,p. 46.

Rao B.K.N., (1996): Handbook of condition monitoring, Edevier Advanced Technology, UK.

Ramden, T., (1995): Condition Monitoring of Fluids Power Pumps and Systems, Unitryck, linkoping university, Sweden.

Rocks, G. and G. Mazur, (1993): Electrical motor controls. American Technical Publication, New York, N.Y, USA.

Roger T. P., (1973): *Life Nature Library: The Birds* (New York: Time-Life Books,p.140.

Trevor L. (2000): Electronic servicing and repair, Butterworth Heinemann Linacre house, Jordan Hill Oxfirdox28DP Inc. Great Britain pp 234, 136, 110.

http://wataniya.yahoo.com/smshistory.html, 2003.

http://www.developershome.com/sms/, 2002, retrieved on 12/10/10.

http://search.datasheetcatalog.net/key/LIGHT+EMITTING+DIODE retrieved on 02/04/11.

http://www.datasheetcatalog.com/datasheets_pdf/E/M/X/- /EMX-300.shtml, retrieved

http://search.datasheetcatalog.net/key/LIQUID+CRYSTAL+DISPLAY+, retrieved on 02/04/11.

http://search.datasheetcatalog.net/key/LM35, retrieved on 02/04/11 . Ibid., Roger Seymour, p. 109. Ibid., Roger Seymour, p. 110.

http://Incubator%20Summary%20%20%20BookRags.com.htm.

http://search.datasheetcatalog.net/key/LIGHT+EMITTING+DIODE , http://www.datasheetcatalog.com/datasheets_pdf/E/M/X/- /EMX-300.shtml, http://search.datasheetcatalog.net/key/LIQUID+CRYSTAL+DISPLAY+)

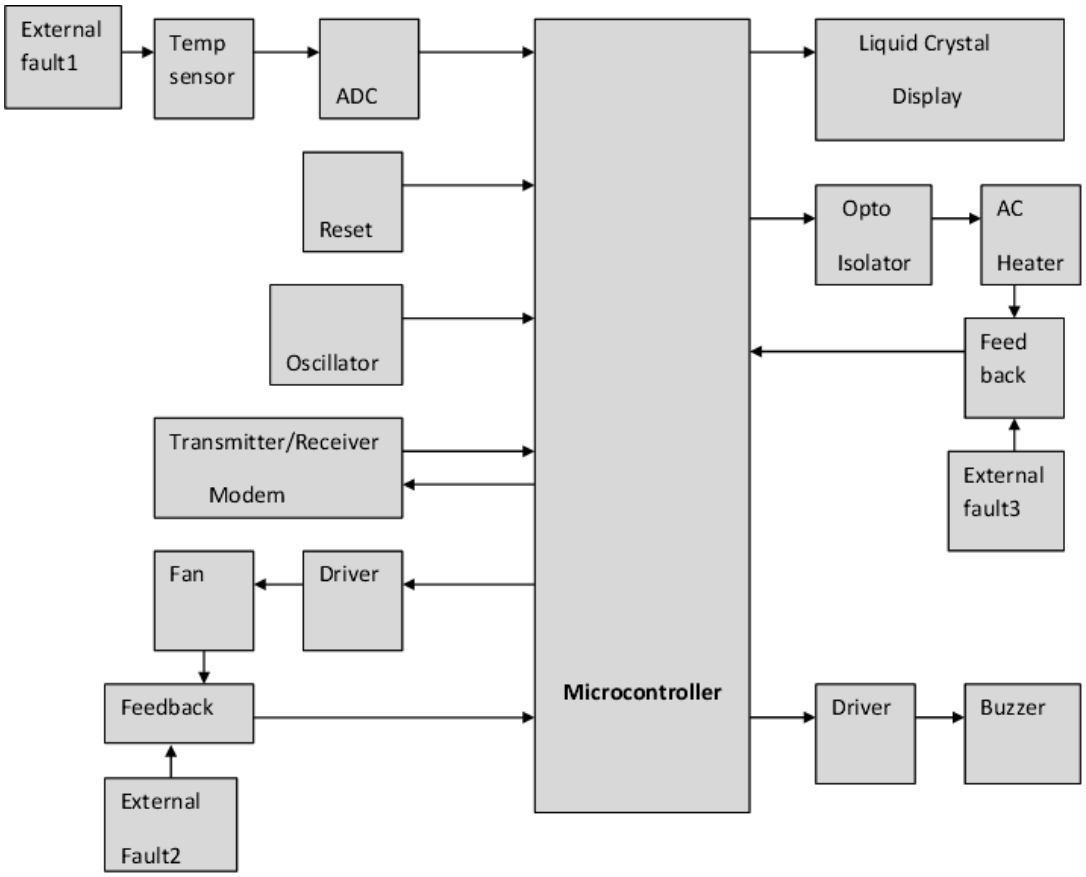


Figure 1: The block diagram overview of the project

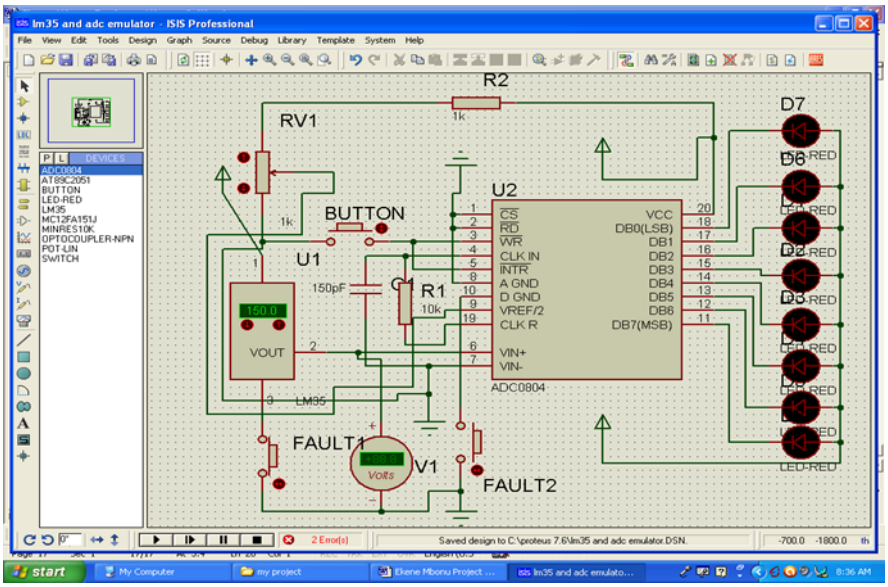


Figure 2: Investigation of how LM35 and ADC0804 work under normal and abnormal conditions (Mazidi and Mazidi, 2000)

Table 1: The result of Investigation of how LM35 and ADC0804 work under normal and fault conditions

Temp (°C)	**V1 (Volt)**	**FAULT1 SWITCH**	**FAULT2 SWITCH**	**ADC Value In binary**	**ADC Value In decimal**	**Inference**
0	0.00	Closed	Closed	00000000	00000000	No fault detected
0	Erratic	Open	Closed	00001110	14	On no power to Sensor, ADC outputs 14v instead of 0volt
1	Erratic	Open	Closed	11111111	255	On no power to Sensor, ADC outputs 255V instead of 1V.
2	Erratic	Open	Closed	11111111	255	On no power to Sensor, ADC outputs 255V instead of 2V.
10	Erratic	Open	Closed	11111111	255	On no power to Sensor, ADC outputs 255V instead of 10V
-55	Erratic	Open	Closed	11111111	255	On no power to Sensor, ADC outputs 255V instead of 10V
Any Other Value	Erratic	Open	Closed	1111111	255	On no power to Sensor, ADC outputs 255V. the exception iat degree temp.
Any Value	No Result	Closed	Open	Simulation Fails	Simulation Fails	In absence of power To ADC, there will be no output

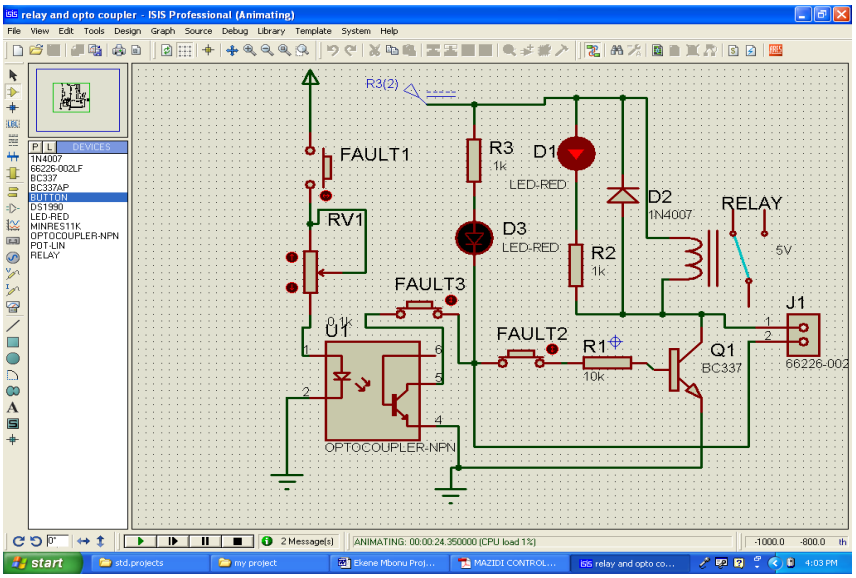


Figure 3: Investigation of how relay and optocoupler work under normal and fault conditions

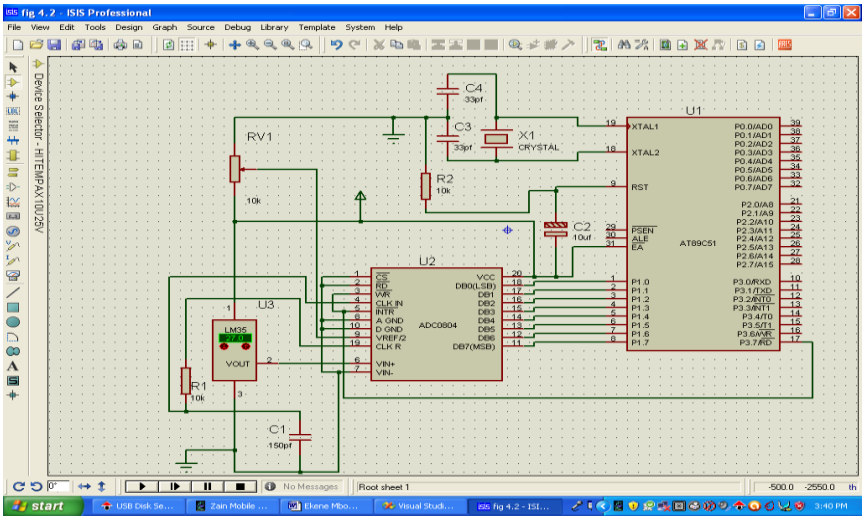


Figure 4: Temperature Interface to the Microcontroller

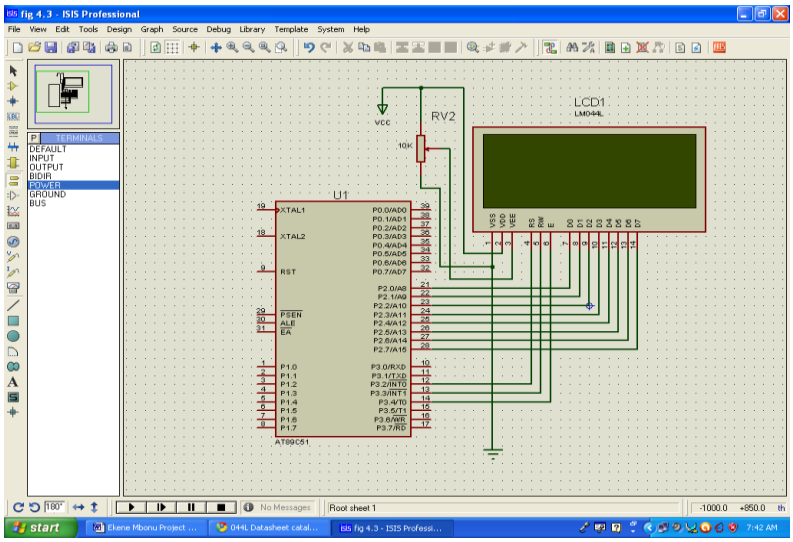


Figure 5: The LCD interface

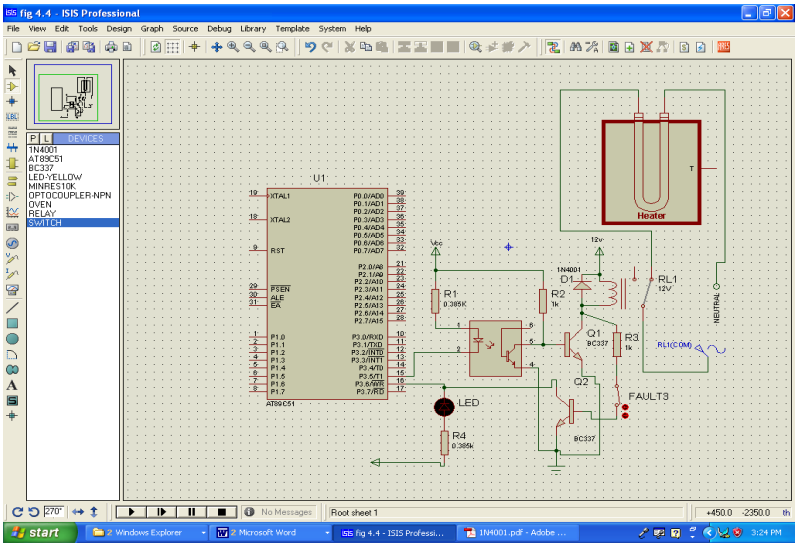


Figure 6: Interfacing AC heater to the controller with feedback

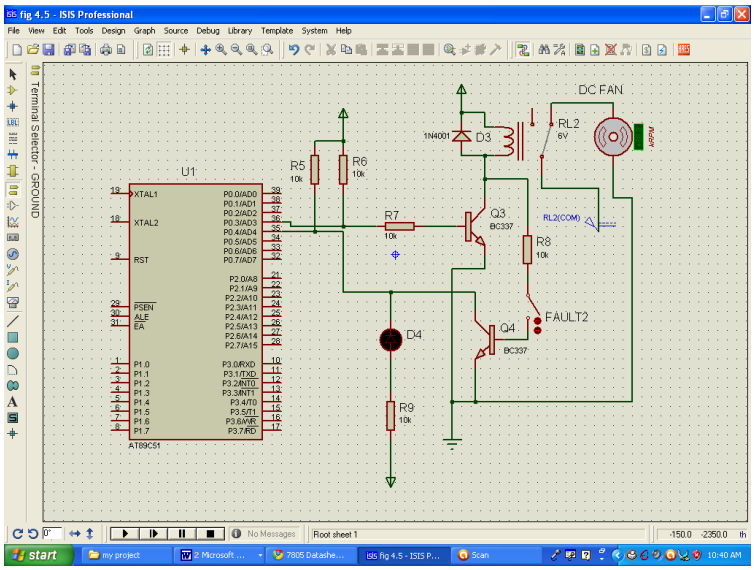


Figure 7: Interfacing DC fan to microcontroller with feedback

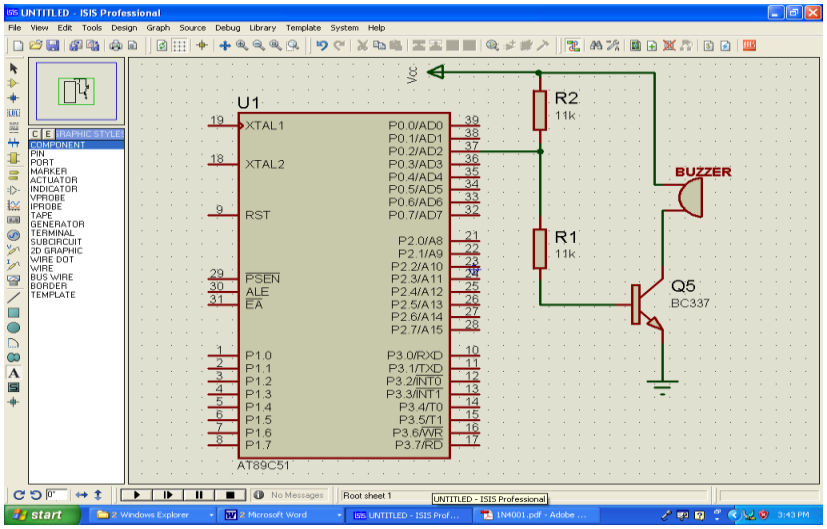


Figure 8: Interfacing the buzzer alarm to microcontroller

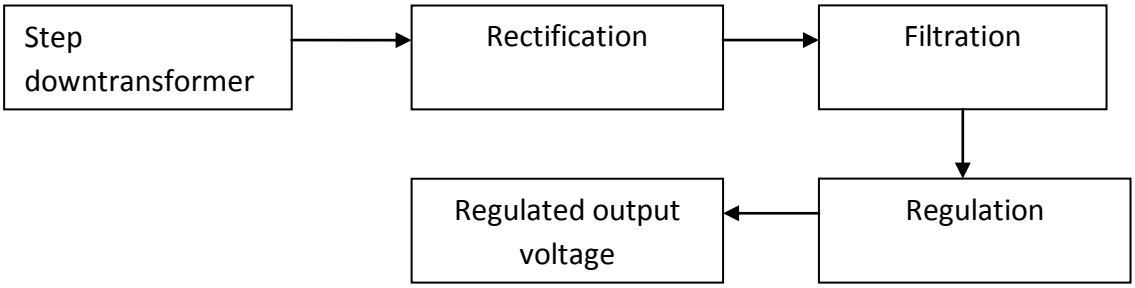


Figure 9: Block diagram of the power supply

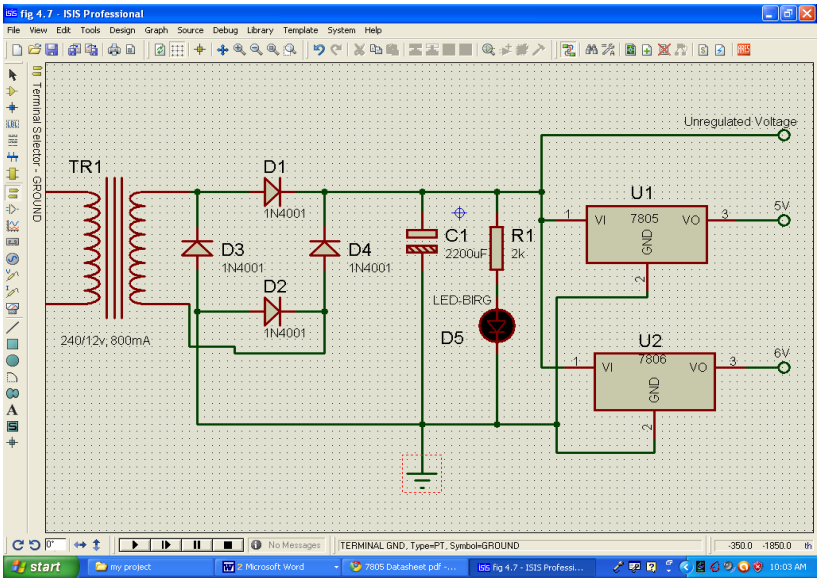


Figure 10: Power supply schematic

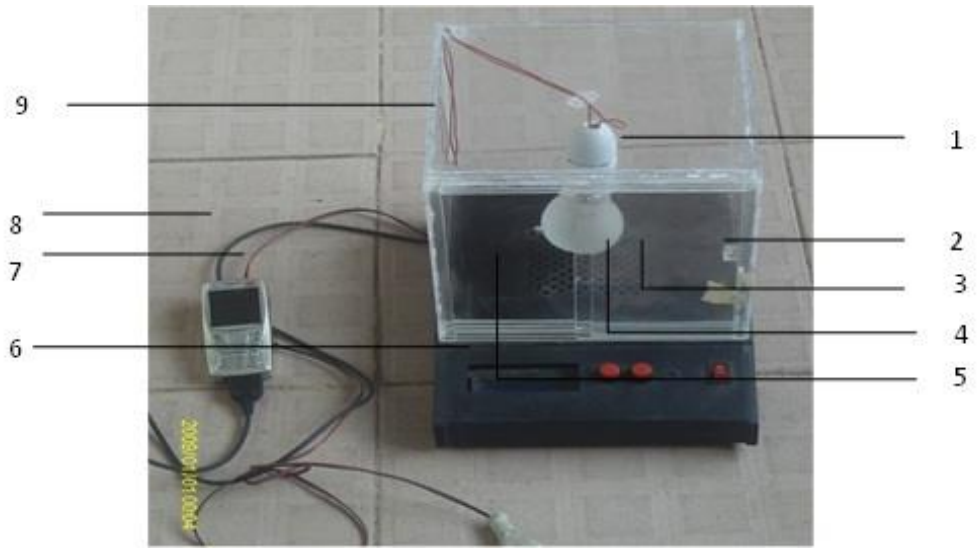


Figure 11: Egg incubator control system with its assembled components. 1 – Heater, 2 – Power switch , 3 ,4 – Reset buttons , 5 – LCD, 6 – Power cable, 7 – HyperTerminal, 8 – Receiver-Transmitter Modem , 9 - Casing

Table 2: System's main features

ITEM	**CONTENT**
Controller IC	AT89C51 microcontroller
Input sensor	LM35
Display Type	4x20 LCD(text)
Dedicated input lines	9
Dedicated output lines	16
Control lines	3
Feedback lines	2
Input mode	Analog
Output mode	Digital(3-5V)
Text Format	Alphanumeric
Operating temperature	34-37°C
Storage temperature	20-80°C

ITEM	**CONTENT**
Power supply	11-20V D.C/220V A.C
Transmitter modem	MY-X7 Sagem phone
Heater	220Va.c/100W electric bulb
Power extension	Yes, one

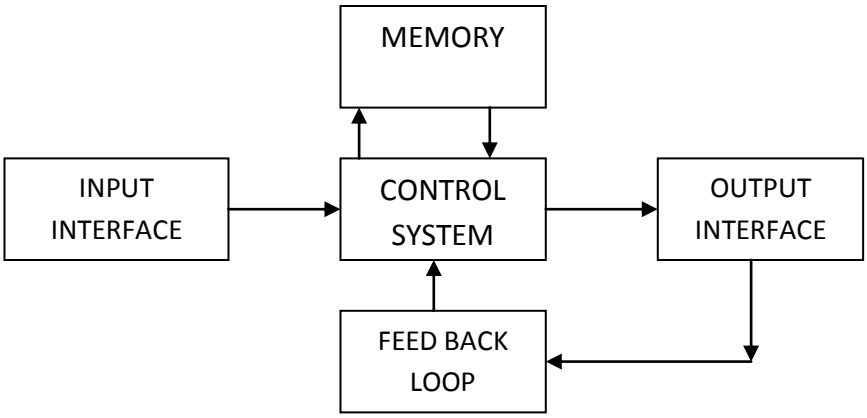
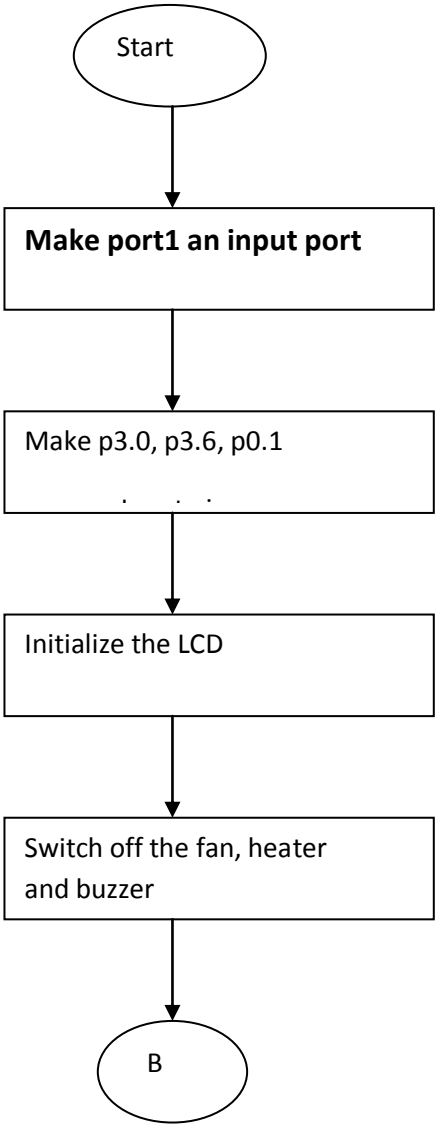
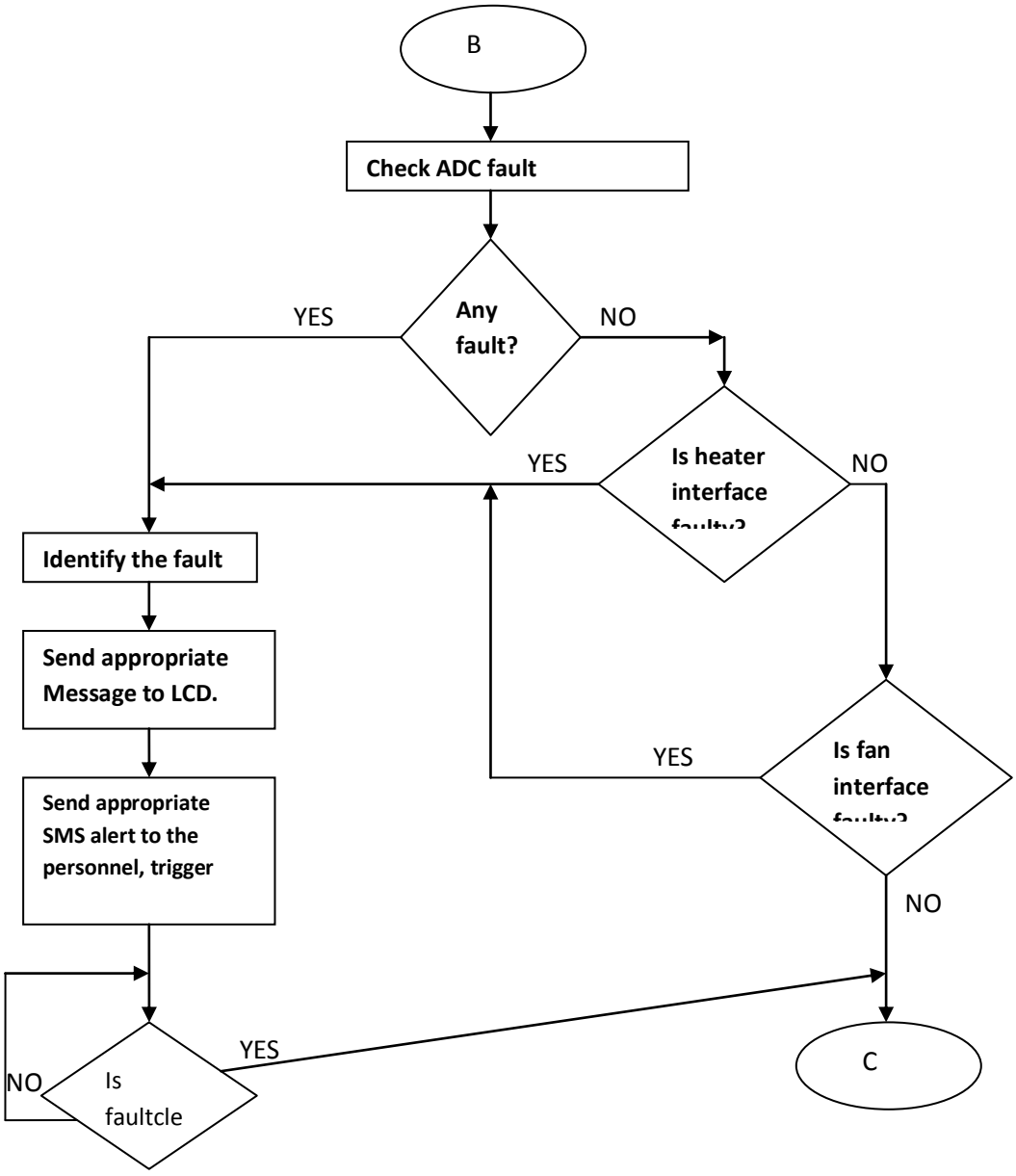


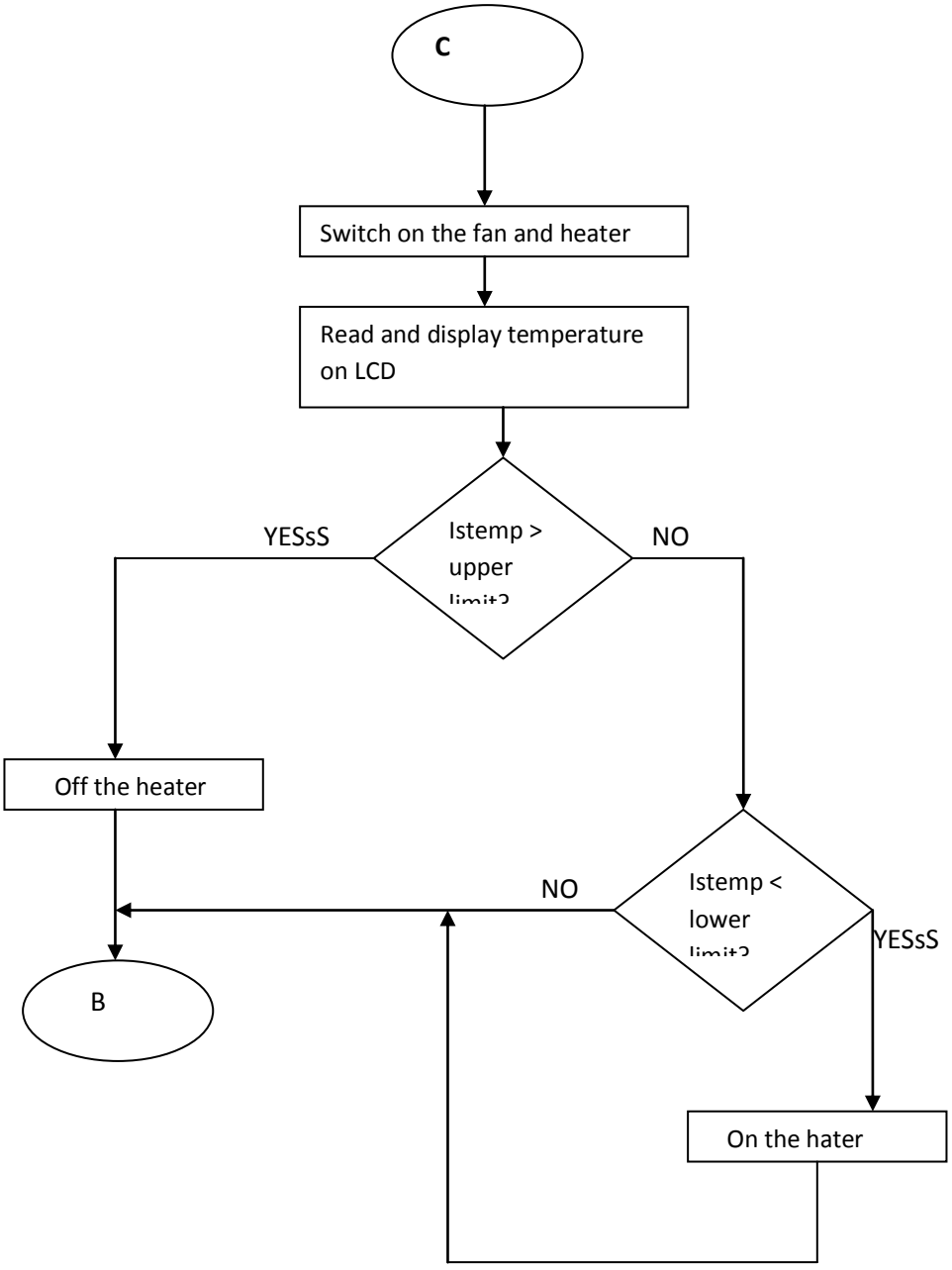
Figure 12: The schematic block diagram of the hardware subsystem


Start
Make port1 an input port
Make p3.0, p3.6, p0.1
. . .
Initialize the LCD
Switch off the fan, heater
and buzzer
B

(a)


B
Check ADC fault
Any fault?
YES
NO
Is heater interface faulty?
YES
NO
Identify the fault
Send appropriate Message to LCD.
Send appropriate SMS alert to the personnel, trigger
Is fan interface faulty?
YES
NO
Is faultcle
YES
NO
C

(b)



(c)

A. Initialization subroutine

B. Serial communication subroutine

C. Monitoring subroutine.

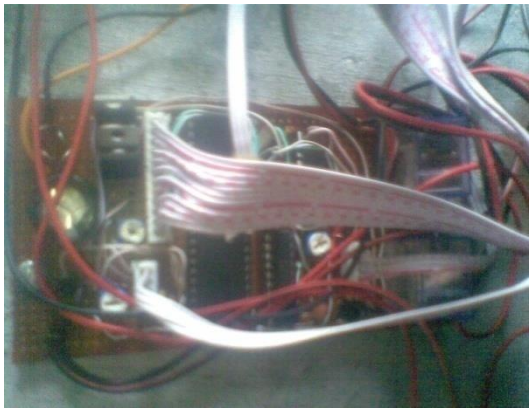
Figure 13: The main flow chart

APPENDICES

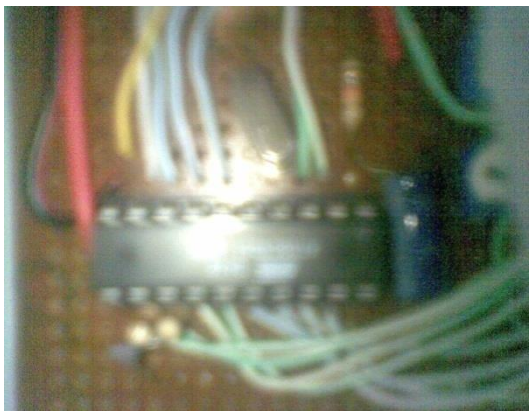
















Sample Codes for Serial Communication between the Phone and the Controller.

```
org 00h                          ; Begin the program from origin
start:      mov scon,#50h        ;configure the serial port mode
            mov TMOD,#20h        ;setting the serial port to receive data
            mov TH1, #-3         ;setting the baud rate to 9,600
            setb TR1             ;enable timer1
send_sms1:  CALL ONESEC          ; wait for one second
            CALL INIT_SMS        ; initialize the phone
            CALL ONESEC          ; wait for one second
            CALL SEND_PHONE_NUM  ; loads personnel phone num.
            CALL ONESEC          ; wait for one second
            CALL SEND_MESSAGE; send appropriate message
End
```

SOME PROPERTIES OF ALMOND FRUITS AS RELATED TO MECHANICAL CRACKING

Alonge, A. F.[1]and Omoniyi, T. E.[2]

[1]Dept. of Agricultural and Food Engineering, University of Uyo, Uyo, Nigeria.
falonge6@yahoo.com

[2]Dept. of Agricultural and Environmental Engineering, University of Ibadan,

Ibadan, Nigeria

ABSTRACT

As parts of steps towards the development of processing and handling equipment for almond seed (Prunusamygdams), some engineering prosperities such as size, sphericity, roundness, volume, density, colour and compression tests were studied. Major diameter varied from 2.567 mm to 4.879 mm with a mean value of 3.234 mm and standard division 0.101 mm. the value of the intermediate diameter varied from 1.306 mm to 1.990 mm with a mean with of 1.735 mm and standard deviation of 0.221 mm. the value of the miner diameter varied from 0.727 mm to 1.182 mm with a mean value of 1.023 mm ad a standard deviation of 0.182 mm.The sphericity of the seed varied from 0.955 mm to 1.174 mm with a mean value of 1.033mm and standard deviation of 0.061 mm. the volume varied from 1.634 mm^3 to 4.661 mm^3 with a mean value of 4.227 mm^3 and standard deviation of 1.124 mm^3. The density varied from 1.176 $glmm^3$ to 1.690 $glmm^3$ with a mean value of 3.266 $glmm^3$ and standard deviation of 1.124 $glmm^3$, load, deformation and energy absorbed at peak are 2637.5 N, 11.033 mm and 12.51 Nm respectively. Load, deformation and energy absorbed at yield are 2009.234 N, 8.411 mm, and 6.261 Nm respectively.

Key Words: deformation, sphericity, density, volume, colour.

1. Introduction

Almond fruits (Prunus amygdams) sometimes grow to 12.2 meters, looks like a peach tree. A fresh almond fruit resembles a gnarled (trees that are rough and covered with hard lumped), unripe peach and grows in clusters. The stone (the almond itself) is covered with a thick, dry, woolly skin. Norman and Desrosier (2005)) described fruits on the other hand, as ripened ovaries of a flower. The edible portion is usually the fleshy covering over the seed, although the seeds are noted previously to be the edible nonfloral or vegetative growths of plants.

By nature almond fruits split open lengthwise down the side, exposing the ripe almond nut. You can easily get the dry kernel by simply cracking open the stone.Almond meats are rich in food value like all nuts. One nut of almonds contains over 35% of the Daily value (Dv) for the antioxidant vitamin E, 21% Dv for magnesium, 80% Dv for calcium and 6% Dv for potassium, as well as 3 grains of dietary fiber. Almond also contain important flavonids (including quercetin and keampferol), plus biotin and sulphur compounds. As the research continues, I'm sure we" 11 hear much more about the remarkable properties of the almond.

Nearly half of the weight of an almond fruits is almond oil. Almond oil is bland-tasting oil though rare, higher grades have a wonderfully sweet aroma. While the non-oil portion of the almond is largely made up of proteins, and carbon virtually no starch, hence their reputation as an alkaline nut. Almonds are the most widely used nut for confectionery items like candy bars, cakes and toppings. Much of the crops is roasted and flavoured or salted and sold in cans, broken and small kernels go to confectionery. About 99% of almonds in the USA are shelled prior to sale and 1% sold in shell. Per capital consumption of almonds is 0.91bs/year doubling over the last 25years. Dietary value, per `100gram edible portion.The almond, known as the king of nuts among dry fruits, is a highly nutritious food. It is rich in almost all the elements needed by tile body. It is an effective health building food, both for the body and mind and a valuable food remedy for several common aliments. Almond oil is used in the cosmetics industry for its penetrating moisturizing and restricting properties. The oil is used as massage oil and is valued as carrier oil when used with essential oil for aromatherapy. The main objective of this study is to determine some physical and mechanical properties of almond fruit relevant to its cracking

No reported work on the engineering properties of almond fruit relevant to cracking was found during this study, except for some properties like volume, density, size, shape, moisture content, hardness and surface area etc. relevant to dehusking. Work has been done on the engineering properties of some biomaterials like melon seed, shea kernel, palm-kernel, grains like sorghum, wheat, millet, castor nut, cocoa nut, cashew nut etc. relevant to their cracking and extraction of oil. Machines have been designed and constructed for some of these crops and more works is skill going on to improve on the design of such machines.

Some agricultural materials are irregular in shape and a complete specification of their form requires an infinite number of measurements for such biomaterials. Mohsenin (1970) said the number of these measurements increases with increase in irregulars of shape as usually involves measurement of several mutually perpendicular axes. For materials with regular dimensions, the sizes are normally defines in terms of weight and thickness. For sometimes now, several researchers have described the size of agricultural products by measuring their physical parts, which are length, width and thickness. These dimensional parameters have been found to be vital to engineers in the design of equipments as feeding unit and other handling accessories associated with processing. Makanjuola (1972) defined the size by measuring its length and thickness i.e. major, intermediate and minor diameters respectively. Mijinyawa and Omolkhoje (2005) measured the three major axes of palm kernels using a vernier sliding caliper with a calibration of 1mm.researchers have described the size of agricultural products by measuring their physical parts, which are length, width and thickness. These dimensional parameters have been found to be vital to engineers in the design of equipments as feeding unit and other handling accessories associated with processing. Makanjuola (1972) defined the size by measuring its length and thickness i.e. major, intermediate and minor diameters respectively. Mijinyawa and Omolkhoje (2005) measured the three major axes of palm kernels using a vernier sliding caliper with a calibration of 1mm.Mohsenin (1979) and Henderson and Perry (1976) noted that moisture content of seeds have an effects on the number of seeds broken during shelling or dehulling and deterioration of seeds in storage, virtually depends on the level of its moisture content.

2. MATERIALS AND METHOD

The almond seeds used in this study were obtained at GAA-AKANBI, Ilorin town, Kwara State. About 200 pieces of the seed were obtained and were divided into the sets, 100 were selected for the physical properties test such as size, shape, volume, density, surface area, coefficient of friction, sphericity and roundness. Also 100 pieces were used for the mechanical properties.The following are the procedure used to determine the physical properties of the seed and some of its mechanical properties.

2.1. Colour and Appearance of the Almond Seed

In determining the colour of the seed, it was done mainly by direct visual observation of the seeds. The colour of the seed when ripe is yellowish-green and green when unripe. The first itself is reddish in colour with a brownish colour as the hard shell of the seed.

2.2. Shape

The shape of the seed is ellipsoid. Shapes were determined in terms of roundness and sphericity using methods described by Curray (1951), Mohsenin (1970) and Dutta*et al.* (1988).

2.3. Measurement of Volume and Density

The volumes and densities of 20 samples of seed randomly selected were determined using the water displacement method described by Shepherd andBhardwad (1980), Alonge and Adigun (1999) and Mohsenin (1972). For density, 20 seeds was selected randomly. The samples were first weighed to get the mass, later the volume was determined for each sample by immersing in water to get the volume of the water displaced using a measuring bucket. Readings were taken immediately the seeds were immersed into the bucket. Density was evaluated as the ratio of each mass of the sample obtained to the volume.

2.4. Surface Area

The surface area of the seeds was determined as described by Dutta*et al.* (1988).

$$\text{Surface Area, } S = 2b^2 + 2ab \sin^{-1} e \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (12)$$

$$\text{Where } e = \{1 - (a/b)^2\}^{1/2}. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (13)$$

a = semi major axis of solid in mm.

b = semi Minor axis of solid in mm.

2.5. Crushing and Compressive Force Using a Universal Testing Machine

The compressive and crushing force test was carried out on a tensiometer. The machine is meant for testing tensile strength of metals, but was modified for this purpose.The machine has a graduated scale of twenty Newton's (20N) internals and maximum range of 600N. The almond seeds used were twenty in all, each sample is however used on the various axis tests, namely; major and intermediate diameter. Placing the seeds between the adjustable plate and ensuring grip before the compression takes place. The almond seeds will be roasted before the compression takes place. The almond seed was roasted before the compression test commenced. The following parameters were determined on almond seeds.

A. i. Load at break.

ii. Deformation break.

iii. Energy absorbed at break.

B. i. Load at peak.
ii. Deformation at peak.
iii. Energy absorbed at peak.

C. i. Load at yield.
ii. Deformation at yield
iii. Energy absorbed at yield.

3. RESULTS AND DISCUSSION

3.1. Seed Size

The principal dimensions, major, intermediate and minor diameters were measured for hundred seeds using a vernier caliper. The results obtained are given in Appendix A. The value of the major diameters ranges from (2.567-3.879)mm with a mean value of 3.234mm and standard deviation of 0.401mm. The value of the intermediate diameter ranges from (1.306-1.990)mm with a mean value of 1.735mm and standard deviation of 0.221mm. The value of the minor diameters of ranges from (0.727-1.182)mm, with a mean value of 1.023mm and a standard deviation of 0.182mm. It was observed that the intermediate, minor and major diameters all have varying mean value and standard deviations.

The major diameter has the highest value of mean and standard deviation of 3.234mm and 0.401 respectively, which indicates that the value of this diameter have the largest spread about the mean and hence the highest variability compared with the two other diameter. Table 1 shows the mean value of the three principal diameters.

3.2. Seed Shape

The mean of the principal dimensions of the seeds in the hundred samples were used to compare the sphericity and roundness as shown in table 1. The sphericity of the almond fruit seeds varies from (0.955-1.174)mm with a mean value of 1.033mm and standard deviation of 0.061mm. The sphericity value indicates that the shape of the seed approximates that of a sphere because of the mean sphericity value is 1.033mm with a very little deviation among the seeds. Thesevalue are shown in table 1. The mean roundness of the sample is given in table 1. The roundness ranges from 6.686 to 7.675mm with a mean value of 7.056mm and standard deviation of 0.098mm.

3.3. Volume and Density

The volume ranges from (1.634 to 4.661)mm^3 with a mean volume of 4.227mm^3 and standard deviation of 1.124mm^3. The density of the sample ranges from (1.176 to 1.690) g/mm^3 with a mean value of 3.266glmm^3 and standard deviation of 1.124g/mm^3 as shown in Table 1. The density of the hundred seeds measured is given in table 1.

3.4. Mechanical Properties

During the compression test, it was observed that load, deformation and energy absorbed at yield are 2009.234N, 8.411mm and 6.261Nm respectively.Load, deformation and energy absorbed at peak are 2637.5N, 11.033mm and 12.518nm respectively. All these are the tests carried out on both the major, minor and intermediate axis and the man values given.The values of load,

deformation and energy at peak for major axis were higher than those at the minor and intermediate axis. Also the values load, deformation and energy at yield for major axis were higher than those at the minor and intermediate axis which should that the greater amount of energy will be required to crack the almond fruit from the major axis than the minor and intermediate axis. Also the almond fruit will yield faster when cracked from the intermediate axis and the minor axis the major axis, since it gives a lower value of load, deformation and energy.

4. CONCLUSIONS

The various investigations on some engineering properties of almond fruits revealed the following: -

1. That the major diameter of the seeds is between (2.567-3.879) mm and the mean value is 3.234mm. The intermediate diameter of the seeds range between (1.306-1.990) mm and the mean value is 1.735mm, the minor diameter of the seeds range between (0.727 –1.182) mm and the mean value is 1. 023mm. It was observe that the values of major, intermediate and minor diameter differ each.
2. The shape of the almond fruits was found to be approximately described as that of a ellipsoid (Elliptical).
3. The average density of the seed was found to be about 3.266g/mm^3
4. The average volume of the seed was found to be 4.227mm^3.
5. The average sphercity and roundness of the seed was found to be 1.033mm and 7.056mm.

REFERENCES

AlongeA. F. (2009) Some Engineering properties of cashew nut.In Press.

Alonge A.F, and Adigun Y.J (1999) Some physical and Aerodynamic properties of sorghum as relate to cleaning. Journal of Pure and Applied Science, vol. 14; pg 992-998.

Dutta, S. K, Nema, S. B and Bherdwaj R. K. (1988) physical properties of grain, journal of Agricultural Engineering Research, Vol. 39; pg. 259 – 268.

Fraser, B. M, Verma S. S and Muir E. E, (1978) Some physical properties of Faba bean, Journal of Agricultural Engineering Research, Vol. 23; pg. 53 – 57.

Igbeka J.C. (1984), Some Mechanical and Rheological properties of Yam and Cassava. Journal of Agricultural Engineering Research Vol.3, No 2, Pg. 45-61

Oje K. (1993) Locust bean pods and seeds. Some Physical Properties relevance to dehulling and seed processing.Journal of Foods Science and Technology. Vol. 30, No.4, Pg, 233-255.

Makanjuola G. A (1972).A study of some physical properties of melon seeds.Journal of Agricultural Engineering Research. Vol. 17, No 3, pg. 128 – 137.

Mijinyawa.Y and Omoikhoje.S (2005), Determination of some physical properties of Palm kernel. Proceedings of the Nigerian Institution of Agricultural Engineers, Vol. 27,No 3 pg. 157 – 164

Mohsenin N. N. (1970) Physical properties of plant and animal materials.Gordon and each Science publisher. New York. Vol. 1, pg. 8 – 11.

Shepherd H. and Bhardwad R.H, (1980), effect of imposed strain and moisture content on some visco elastic characteristic of cowpeas. Journal of Agricultural Engineering.Research vol. 39, No 3, pg 209 – 210.

Table 1: Some Engineering properties of Almond fruit

S/n	Property	Minimum Value	Mean Value	Maximum Value	Standard Deviation
1	Major diameter	2.567	3.234	3.879	0.401
2	Minor diameter	0.727	1.023	1.182	0.182
3	Intermediate diameter	1.306	1.735	1.990	0.221
4	Sphericity	0.955	1.033	1.174	0.061
5	Roundness	6.686	7.056	7.675	0.098
6	Density	1.176	1.541	1.690	0.159
7	Volume	1.634	3.266	4.661	1.124
8	Load @peak (N)	1039.700	2637.500	4136.500	1291.900
9	Deformation @peak mm	5.4070	11.033	22.771	6.573
10	Strain @ peak (%)	15.906	35.902	50.602	15.073
11	Energy @ peak (Nm)	3.195	12.518	39.556	16.448
12	Load @break (N)	998.900	1881.900	3534.500	987.700
13	Deformation @break mm	5.954	15.019	23.384	7.161
14	Strain @ break (%)	16.108	39.370	51.964	17.170
15	Energy @ break (Nm)	14.785	14.785	41.925	18.900
16	Load @ yield (N)	387.200	2009.230	3080.300	1000.200
17	Deformation @ yield (mm)	3.309	8.411	15.194	4.467
18	Strain @ yield (%)	7.607	28.689	38.531	9.619
19	Energy @ peak (Nm)	0.558	6.261	13.729	5.148

AGRICULTURAL WASTE CONCEPT, GENERATION, UTILIZATION AND MANAGEMENT

Obi, O. F.[1], Ugwuishiwu, B. O.[2] and Nwakaire, J. N.

[1]Agricultural and Bioresources Engineering Department, University of Nigeria, Nsukka.francis.obi@unn.edu.ng
[2]Project Development Institute (PRODA), Enugu.ugwuishiwu.boniface@unn.edu.ng

ABSTRACT

Agricultural wastes are non-product outputs of production and processing of agricultural products that may contain material that can benefit man but whose economic values are less than the cost of collection, transportation, and processing for beneficial use. Estimates of agricultural waste arising are rare, but they are generally thought of as contributing a significant proportion of the total waste matter in the developed world. Agricultural development is usually accompanied by wastes from the irrational application of intensive farming methods and the abuse of chemicals used in cultivation, remarkably affecting rural environments in particular and the global environmental in general. Generally, agricultural wastes are generated from a number of sources notably from cultivation, livestock and aquaculture. These wastes are currently used for a number of applications through the '3R' strategy of waste management. Agricultural waste management system (AWMS) was discussed and a typical waste management options for a poultry farm was also described using the six agricultural waste management functions. Agricultural waste has a toxicity potential to plant, animals and human through many direct and indirect channels. The effects of these toxic agricultural wastes on the environment were discussed as well as their management.

Keywords: Agricultural waste, generation, management

1.0 Introduction

Agricultural wastes are defined as the residues from the growing and processing of raw agricultural products such as fruits, vegetables, meat, poultry, dairy products, and crops. They are the non-product outputs of production and processing of agricultural products that may contain material that can benefit man but whose economic values are less than the cost of collection, transportation, and processing for beneficial use. Their composition will depend on the system and type of agricultural activities and they can be in the form of liquids, slurries, or solids. Agricultural waste otherwise called agro-waste is comprised of animal waste (manure, animal carcasses), food processing waste (only 20% of maize is canned and 80% is waste), crop waste (corn stalks, sugarcane bagasse, drops and culls from fruits and vegetables, prunings) and hazardous and toxic agricultural waste (pesticides, insecticides and herbicides, etc). Estimates of agricultural waste arising are rare, but they are generally thought of as contributing a significant proportion of the total waste matter in the developed world. Expanding agricultural production has naturally resulted in increased quantities of livestock waste, agricultural crop residues and agro-industrial by-products. There is likely to be a significant increase in agricultural wastes globally if developing countries continue to intensify farming systems. It is estimated that about 998 million tonnes of agricultural waste is produced yearly (Agamuthu, 2009). Organic wastes can amount up to 80 percent of the total solid wastes generated in any farm (Brown & Root,

1997) of which manure production can amount up to 5.27 kg/day/1000 kg live weight, on a wet weight basis (Overcash, 1983).

2.0 AGRICULTURAL WASTE GENERATION

As earlier noted, agricultural development is usually accompanied by wastes from the irrational application of intensive farming methods and the abuse of chemicals used in cultivation, remarkably affecting rural environments in particular and the global environmental in general. The waste generated is dependent on the type of agricultural activities carried out.

2.1 Wastes from cultivation activities

While tropical climate is favorable for growing crops, it also supports thegeneration and development of insects and weeds. This situation creates a high demand forpesticides in order to kill insects and protect against the spread of epidemic diseases; this need often lead to the abuse of pesticides by farmers. After using pesticides, most of the bottles andpackages holding these pesticides are thrown into fields or ponds. According to an estimate made bythe Plant Protection Department (PPD), about 1.8% of the chemicals remain in their packaging (Dien andVong, 2006).These wastes have the potential to cause unpredictable environmental consequences such as foodpoisoning, unsafe food hygiene and contaminated farmland due to their potentially lasting and toxicchemicals. In addition to this, existing stagnant or unused pesticides and pesticide packages withresidue from the original contents poses serious environmental consequence in that they could be stored or buried in the wrong waywhich may leak or enter theenvironment through osmosis and thereby affecting the environment.

In agricultural production for example, fertilizers play an important role in maintaining the productivity andquality of plants. Inorganic fertilizer is inexpensive and characterized by high productivity.However,many farmers apply more fertilizer to their crops than the amount needed by the plants (Hai and Tuyet, 2010). The seriousconsequence of such an excessive application of fertilizer is that it is used to the point of abuse in order to increase the annualagricultural output.The rate of absorption of such fertilizer compounds (nitrogen, phosphorus, and potassium) varies dependingon the land characteristics, plant types, and method of fertilization (Thao, 2003).Among the fertilizer excess, a portion is retained in thesoil, a portion enters ponds, lakes and/or rivers as a result of either surface runoff or the irrigation system adopted,which results in the pollution of surface water; a portion enters the ground water, and a portionevaporates or becomes denitrated, causing air pollution.

2.2 Wastes from livestock production

Waste from livestock activities include solid waste such as manure and organic materials in theslaughterhouse; wastewater such as urine, cage wash water, wastewater from the bathing of animalsand from maintaining sanitation in slaughterhouses; air pollutants such as H_2S and CH_4; and odors.The pollution caused by livestock production istherefore a serious problem since most of them are usually built around residential areas.Air pollution includes odors emanating from cages resulting from the digestion process of livestock wastes; the putrefaction process of organic matter in manure; animal urine, and/or from redundant foods. The intensity of the smell depends on animal density, ventilation, temperature, and humidity. The proportion of NH_3, H_2S, and CH_4 varies along with the stages of the digestion process and also depends on organic materials, the components of foods, microorganisms, and the status of the animals' health. Thisuntreated and non-reusable waste source can generate greenhouse gases while also having negativeeffects on the fertility of the soil and causing water pollution.In livestock waste, water volume accounts for

75–95% of total volume, while the rest includesorganic matter, inorganic matter, and many species of microorganisms and parasite eggs (Hai and Tuyet, 2010). Thosegerms and substances can spread diseases to humans and cause many negative effects on the environment.

2.3 Waste from aquaculture

The growth in aquaculture has led to an increase in the use of feeds for improved production. The amount of feed used in a system is the most important factor used in determining the quantity of waste generated. The wastes that result from the use of aquaculture feeds are discussed in this section of the report and it is a summary of the information provided by Miller and Semmens (2002). One of the major wastes generated in aquaculture is metabolic waste which could be dissolved or suspended. In a properly managed farm, approximately 30% of the feed used will become solid waste. Feeding rates are dependent on the ambient temperature. Increase in temperature results in increased feeding which gives rise to increased generated waste. Water flow patterns in production units are important for waste management because a proper flow will minimize the fragmentation of fish feces and allow for rapid settling and concentration of the settleable solids. This can be critical because a high percentage of non-fragmented feces can be quickly captured which will greatly reduce the dissolved organic waste (Mathieu and Timmons, 1995).

3.0 WASTE UTILIZATION ROUTES

Agricultural waste utilization technology must either use the residues rapidly, or store the residues under conditions that do not cause spoilage or render the residues unsuitable for processing to the desired end product. There are a number of applications to which these wastes can be used. They include:

3.1 Fertilizer application

The utilization of animal manures for fertilizer has a definite impact on input energy requirements at the farm level (Timbers and Downing, 1977). Manure could supply 19, 38 and 61% of nitrogen, phosphorus and potassium in chemical fertilizer (Council forAgricultural Science and Technology, 1975). However, fertilizer use of manures from large confinement is associated with high energy costs for transport, distribution, storage facility requirements, odour problems and possibility of groundwater contamination.Mokwunye (2000) reported that poultry manure contain high phosphorus which has positive effect on the growth and productivity of crops. It is also effective when combined with mineral phosphorus fertilizer for farm use. Adding manure to soil increases its fertility because it increases the nutrient retention capacity (or cation exchange capacity), improves the physical condition, the water-holding capacity and the soil structure stability.

3.2 Anaerobic digestion

Methane gas can be produced from agricultural wastes particularly manures. The gas is best suited for heating purposes as in broiler operation, water heating, grain drying, etc. The anaerobic digestion of agricultural waste to form methane-rich gas is a two-step microbial fermentation. Initially, acid-forming bacteria break down the volatile solids to organic acids which are then utilized by methanogenic organisms to yield methane-rich gas (Figure 3.1). The composition of the typical gas produced is: methane, 50-70%; CO_2, 25-45%; N_2, 0.5-3%; H_2, 1-10% with traces of H_2S; and the heating value of the gas is in the range of 18-25 MJ/m^3 (Timbers and Downing, 1977). Some of the major disadvantages of the digestion system are the high capital costs and the explosive properties of the methane gas. However, the advantages far outweigh the

aforementioned disadvantages. Anaerobic digestion makes the treatment and disposal of large poultry, swine and diary waste feasible, minimizing the odor problem. It stabilizes the waste and the digestion sludge is relatively odour-free and yet retains the fertilizer value of the original waste.

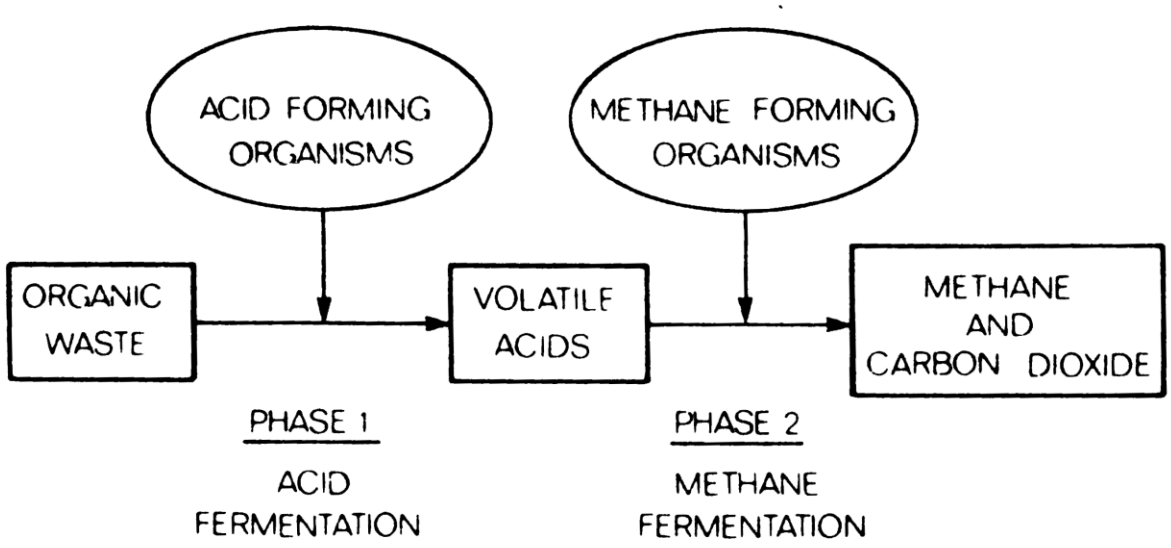


Figure 3.1: Methane production by two-stage microbial fermentation
Source: Timbers and Downing (1977)

3.3 Adsorbents in the elimination of heavy metals

Excessive release of heavy metals into the environment due to industrialization and urbanization has posed a great problem worldwide. Unlike organic pollutants, the majority of which are susceptible to biological degradation, heavy metal ions such as copper, cadmium, mercury, zinc, chromium and lead ions do not degrade into harmless end products (Gupta et al., 2001). The presence of heavy metal ions is a major concern due to their toxicity to many life forms. Studies on the treatment of effluent bearing heavy metal have revealed adsorption to be a highly effective technique for the removal of heavy metal from waste stream and activated carbon has been widely used (Chand et al., 1994). In recent years, agricultural wastes have proven to be a low cost alternative for the treatment of effluents containing heavy metals through the adsorption process. The low cost agricultural waste such as sugarcane bagasse (Mohan and Singh, 2002), rice husk (Ayub et al., 2002), sawdust (Ajmal et al., 1996), coconut husk (Tan et al., 1993), oil palm shell (Khan et al., 2003), neem bark (Ayub et al., 2001), etc., for the elimination of heavy metals from wastewater have been investigated by various researchers.

3.4 Pyrolysis

In pyrolysis systems, agricultural waste is heated up to a temperature of 400-600°C in the absence of oxygen to vaporize a portion of the material, leaving a char behind. This is considered to be a higher technology procedure for the utilization of agricultural wastes. Others are hydrogasification, and hydrolysis. They are used for the preparation of chemicals from agricultural waste as well as for energy recovery. Of particular interest to agriculture are the

preparation of alcohols for fuel, ammonia for fertilizers, glucose for food and feed. Pyrolysis of agricultural waste yields oil, char and low heating value gas.

3.5 Animal feed

In most developing countries, the problem with animal feed is in the limited availability of protein sources although great efforts are being made to find alternative supplements (Leng et al., 1992). Crop residues have high fiber content and are low in protein, starch and fat. Therefore, the traditional method of increasing livestock production by supplementing forage and pasture with grains and protein concentrate may not meet future meat protein needs. Use of the grain and protein for human food will compete with such use for animal feed. These problems may be circumvented by utilizing residues to feed domesticated animals (Hussein and Sawan, 2010).

3.6 Direct combustion

The simple act of burning agricultural waste as fuel is one of the oldest biomass conversion processes known to mankind. Complete combustion of agro-waste "consists of the rapid chemical reaction (oxidation) of biomass and oxygen, the release of energy, and the simultaneous formation of the ultimate oxidation products of organic matter – CO_2 and water" (Klass, 1998). The energy released is usually in the form of radiant and thermal energy provided oxidation occurs at sufficient rate; the amount of which is a function of the enthalpy of combustion of the biomass. If agricultural waste is to be utilized efficiently through thermal conversion process, there is need to fabricate these biomass wastes into solid form. It is usually burnt for heating, cooking, charcoal production, and the generation of steam, mechanical and electric power applications. Of all the processes that can be used to convert agricultural waste to energy or fuels, combustion is still the dominant technology accounting for more than 95% of all biomass energy utilized today (Klass, 1998).

4.0 AGRICULTURAL WASTE MANAGEMENT SYSTEM (AWMS)

Recently, agricultural waste management (AWM) for ecological agriculture and sustainable development has become an issue of concern for policy makers (Hai and Tuyet, 2010). The usual approach to agricultural waste management has been discharge to the environment with or without treatment. There is need to consider wastes as potential resources rather than undesirable and unwanted, to avoid contamination of air, water, and land resources, and to avoid transmission of hazardous materials. This will require better use of technology and incentives, a change in philosophy and attitudes, and better approaches to agricultural waste management. The organic wastes, especially manure generated by animals, if improperly managed or left untreated can result in significant degradation of soil, water and air quality. Stagnant wastes provide a medium in which flies breed and diseases are transmitted. Uncontrolled decomposition of organic wastes produces odorous gases as well as ammonia volatilization, leading to acid rain (Wright, 1998). Because of the intensification of animal production on a small area of land, there are increasing concerns about:

- Water quality resulting from higher nitrogen and phosphorous loadings;
- Pathogens and antimicrobial compounds in the manure;
- Foul odors and air quality from ammonia, methane and nitrous oxide emissions;
- Soil quality because of potassium and phosphorous loading (Fabian, et al, 1993).

An Agricultural Waste Management System (AWMS), according to USDA (2012) is a "planned system in which all necessary components are installed and managed to control and use

byproducts of agricultural production in a manner that sustains or enhances the quality of air, water, soil, plant, and animal resources". Such a system is developed using total systems approach, i.e. it is designed to cater for all the waste associated with agricultural production to utilization throughout the year round. The Total Solids (TS) concentration of agricultural wastes is the main characteristic that determines the handling of the material. For excreted manure for example, the following factors affect the TS concentration and they include the climate, type of animal, amount of water consumed by the animal, and the feed type. In most systems the consistency of the waste can be anticipated or determined. The TS concentration of the waste can be increased by adding beddings or other solid waste to the waste, decreased by adding water, and stabilized by protecting it from additional water. The TS concentration is important in that it affects the total volume of the waste to be handled. Liquid waste management systems are often easier to automate and manage than those for solid wastes; however the initial cost of the liquid handling equipment may be greater than that for solid waste systems (USDA, 2012).

AWMS consist of six basic functions (Figure 4.1) as noted by USDA (2012). These are production, collection, storage, treatment, transfer, and utilization.Production is a function of the amount and nature of agricultural waste generated. The waste requires management if quantities produced is sufficient enough to become a resource concern. A complete analysis of production includes the kind, consistency, volume, location, and timing of the waste produced. Collection refers to the initial capture and gathering of the generated waste from the point of origin or deposition. The AWMS plan should identify the method of collection, location of the collection points, scheduling of the collection, labor requirements, necessary equipment or structural facilities, management and installation costs of the components, and the impact that collection has on the consistency of the waste. The storage function has to do with the temporary containment or holding of the waste.The storage facility of a waste management system provides control over the schedulingand timing of the system functions such as the treatment and application or use of the waste which could be affected by weather or interfered with by other operations. The waste management system should identify thestorage period; the required storage volume; the type,estimated size, location, and installation cost of thestorage facility; the management cost of the storageprocess; and the impact of the storage on the consistencyof the waste.

Treatment is anyfunction designed to reduce thepollution or toxic potential of the waste, including physical,biological, and chemical treatment and increases its potential beneficial use. It includes pre- treatment activities such as analysis of the characteristics of the waste beforetreatment; a determination of the desired characteristicsof the waste following treatment; the selection ofthe type, estimated size, location, and the installationcost of the treatment facility; and the managementcost of the treatment process. Transfer refers to the movement and transportation of thewaste throughout the system from the collection to the utilization stage either as a solid, liquid, or slurry, depending on the total solids concentration. Utilization is the application of the waste for beneficial use and it includes recycling reusable waste productsand reintroducing non-reusable waste products into theenvironment (USDA, 2012).

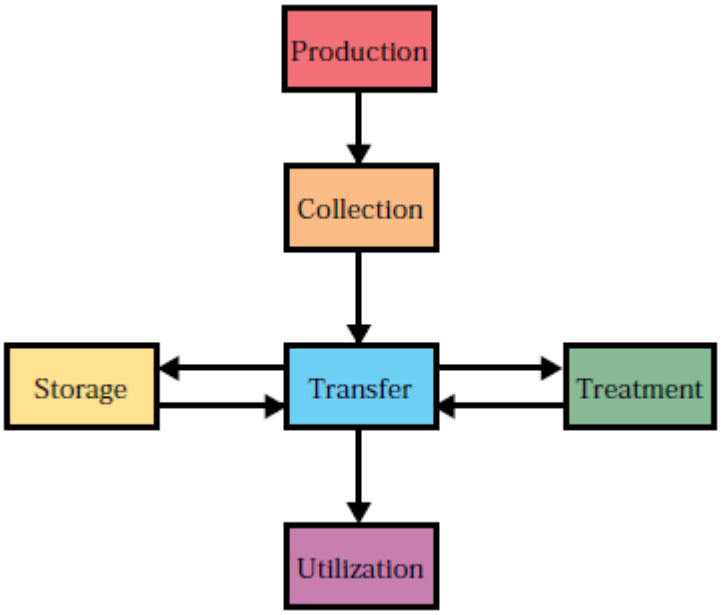


Figure 4.1: Agricultural Waste Management Functions
Source: USDA (2012)

4.1 The '3R' Approach to AWM

The concept of minimizing waste reduces the quantity and ill-effects of waste generation by Reducing quantity of wastes, Reusing the waste products with simple treatments and Recycling the wastes by using it as resources to produce same or modified products. This is usually referred to as '3R'. Some waste products can be consumed as resources for production of different goods or the same product, meaning recycling the same resource. When wastes are reused time and again, it offsets harvesting of new similar or same products. This saves fresh resources exploitation and reduces waste generation. All in all, the 3Rs individually or collectively saves fresh resources exploitation, add value to the already exploited resources and very importantly minimizes the waste quantity and its ill effects. The principle of reducing waste, reusing and recycling resources and products (3Rs) aims at achieving efficient minimization of waste generation by:

- Choosing to use items with care to reduce the amount of waste generated.
- Repeated use of items or parts of items which still have usable aspects.
- The use of waste itself as resources.

4.2 The 3R Hierarchy in AWM

Waste minimization efficiency is stated to be better achieved applying 3Rs in a hierarchical order- Reduce, Reuse and Recycle (Figure 4.3).The waste hierarchy refers to the "3Rs" i.e., reduce, reuse and recycle, which classify waste management strategies according to their desirability. The 3Rs are meant to be a hierarchy, in order of importance. The waste hierarchy has taken many forms over the past decade, but the basic concept has remained the foundation of most waste minimization strategies. The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste. The 3R approach

as noted by Hai and Tuyet (2010) is conventionally expressed through a pyramid hierarchy in which increase in environmental benefits of each approach is placed from bottom to top.

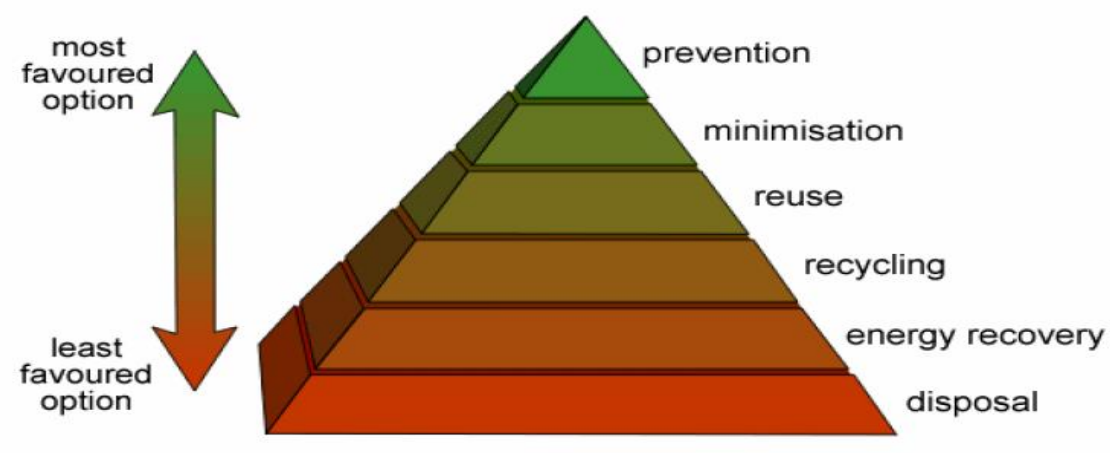


Figure 4.3: The 3Rs Hierarchy
Source: Department of Environment (2010)

4.3 Typical Poultry Waste Management Options

A poultry farm is used here to describe a typical waste management system showing the application of each component function of an AWMS. The poultry waste management system is as described in USDA (2012). A holistic view of the various waste management options for poultry production in shown in Figure 4.2.

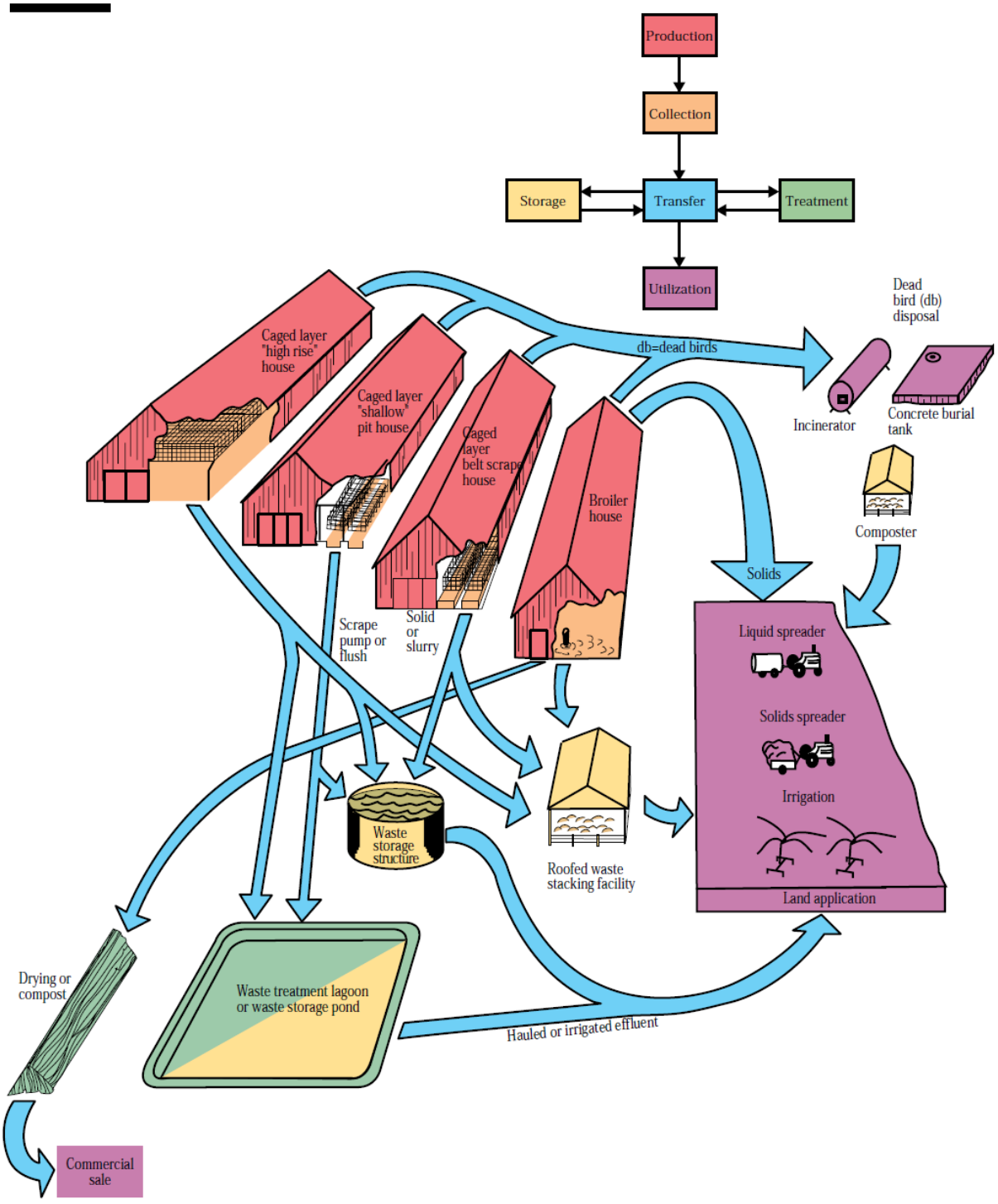


Figure 4.2: Poultry Waste Management Options
Source: USDA (2012)

i. **Production:** Wastes associated with poultry operations include manure and dead poultry. Depending upon the system, waste can also include litter, wash-flush water, and waste feed.

ii. **Collection:** The manure from poultry operations is allowed to accumulate on the floor where it is mixed with the litter. The manure litter pack forms a "cake" that generally is removed between flocks. The litter pack can be removed frequently to prevent disease transfer between flocks. In layer houses, the manure that drops below the cage is collected in deep stacks or is removed frequently using either a shallow pit located beneath the cages for flushing or scraping or belt scrapers positioned directly beneath the cages.

iii. **Storage:** Litter from poultry operations is stored on the floor of the housing facility or outside the housing facility. When it is removed, it can be transported directly to the field for land application. In some areas the litter may be compacted in a pile and stored in the open for a limited time; however, it generally is better to cover the manure with a plastic or other waterproof cover until the litter can be used. But if it is needed to be stored for a long time, the litter should be stored in a roofed facility. If the manure from layer operations is kept reasonably dry, it can be stored in a roofed facility. If it is wet, it should be stored in a structural tank or an earthen storage pond.

iv. **Treatment:** Poultry litter can be composted. This stabilizes the litter into a relatively odorless mass and helps to kill disease organisms so that the litter can be reused as bedding or supplemental feed to livestock. The litter can also be dried and burned directly as a fuel. Liquid manure may be placed into an aerobic digester to produce methane gas.

v. **Transfer:** The method used to transfer the waste depends on the total solid content of the waste. Liquid waste can be transferred in pipes, gutters, or tank wagons, and dried litter can be scraped, loaded, hauled as a solid and transported using trucks.

vi. **Utilization:** The waste from poultry facilities can be used for agricultural land application or sold because of the high nutrient value of the litter. Furthermore, poultry waste can also be used for the production of methane gas, buried directly as a fuel, reused as bedding, or used as a feed supplement to livestock.

5.0 CONCLUSION

Agricultural wastes are residues from the growing and processing of raw agricultural products are non-product outputs of production and processing and may contain material that can benefit man. These residues are generated from a number of agricultural activities and they include cultivation, livestock production and aquaculture. These wastes when managed properly through the application of the knowledge of agricultural waste management systems such as the "3Rs" can be transformed into beneficial materials for human and agricultural usage.

REFERENCES

Agamuthu, P. (2009). Challenges and opportunities in Agro-waste management: An Asian perspective. Inaugural meeting of First Regional 3R Forum in Asia 11 -12 Nov., Tokyo, Japan.

Ajmal, M., Rao, R. A. K., and Siddiqui, B. A. (1996).Studies on Removal and Recovery of Cr (VI) from Electroplating Wastes. Water Res. 30(6): 1478-1482.

Ayub, S., Ali, S. I. and Khan, N. A. (2002). Adsorption studies on the low cost adsorbent for the removal of Cr(VI) from electroplating wastewater. Environmental Pollution Control Journal 5(6): 10 – 20.

Ayub, S.,Ali, S.I., and Khan, N.A. (2001). Efficiency evaluation of neem (Azadirachtaindica) bark in treatment of industrial wastewater. Environmental Pollution Control Journal 4(4): 34 – 38.

Brown and Root Environmental Consultancy Group (1997). Environmental review of national solid waste management plan. Interim report submitted to the Government of Mauritius.

Chand, S., Aggarwal V.K. and Kumar P., (1994).Removal of Hexavalent Chromium from the Wastewater by Adsorption. Indian J Environ. Health, 36(3): 151-158.
Council for Agricultural Science and Technology (1975).Utilization of animal manures and sewage sludge in food and fiber production. Repot No. 41.
Department of Environment (2010).National 3R strategy for waste management.Ministry of Environment and Forests, Government of the People's Republic of Bangladesh.
Dien, B. V. and Vong, V. D. (2006). Analysis of pesticide compound residues in some water sources in the province of Gia Lai and DakLak. Vietnam Food Administrator.
Fabian, E. E., Richard, T. K. D., Allee, D. and Regenstein, J. (1993). Agricultural composting: A feasibility study for New York farms. (available at www.cfe.cornell.edu/).
Gupta, V. K., Gupta, M. and Sharma, S. (2001). Process development for the removal of lead and chromium from aqueous solution using red mud – an aluminum industry waste. Water Res. 35(5): pp. 1125 – 1134.
Hai, H. T. and Tuyet, N. T. A. (2010). Benefits of the 3R approach for agricultural waste management (AWM) in Vietnam. Under the Framework of joint Project on Asia Resource Circulation Policy Research Working Paper Series. Institute for Global Environmental Strategies supported by the Ministry of Environment, Japan.
Hussein, S. D. A. and Sawan, O. M. (2010).The Utilization of Agricultural Waste as One of the Environmental Issues in Egypt (A Case Study). Journal of Applied Sciences Research, 6(8): 1116-1124.
Khan, N. A., Shaaban, M. G., Hassan, M. H. A., (2003).Removal of heavy metal using an inexpensive adsorbent. Proc. UM Research Seminar 2003 organized by Institute of Research Management and Consultancy (IPPP), University of Malaya, Kuala Lumpur.
Klass, D. L. (1998).Biomass for renewable energy, fuels, and chemicals.Academic Press.
Leng, R. A., Choo, B. S. and Arreaze, C. (1992).Practical technologies to optimize feed utilization by ruminants. In: A Speedy and P L Pugliese (Editors). Legume Trees and Other Fodder trees as Protein Sources for Livestock. FAO, Rome, Italy, pp:145-120.
Mathieu, F. and Timmons, M. B. (1995) Techniques for Modern Aquaculture. J. K. Wang (ed.), American Society of Agricultural Engineers, St. Joseph, MI
Miller, D. and Semmens, K. (2002).Waste Management in Aquaculture.Aquaculture information series, Extension Service, West Virginia University.
Mohan, D. and Singh, K. P. (2002).Single and Multi-Component Adsorption of Cadmium and Zinc using Activated Carbon Derived from Bagasse – An Agricultural Waste. Water Research, 36: 2304-2318.
Mokwunye, U. (2000). Meeting the phosphorus Needs of the soils and crops of West Africa: The Role of Indigenous Phosphate rocks. Paper presented on Balanced Nutrition Management systems for the Moist Savanna and Humid Forest Zones of Africa at a symposium organized by IITA at Ku Leuva at Cotonun, Benin Republic, October 9-12.
Overcash, M. R. (1983). Livestock waste management, F. J. Humenik& J. R. Miner, eds. CRC Press, Boca Raton. ISBN 0-8493-5596-6.
Tan, W. T., Ooi, S. T., and Lee, C. K. (1993). Removal of Chromium (VI) from Solution by Coconut Husk and palm Pressed Fibre. Environmental Technology, 14: 277-282.
Thao, L. T. H. (2003). Nitrogen and phosphorus in the environment.Journal of Survey Research.Hanoi University of Civil Engineering.
Timbers, G. E. and Downing, C. G. E. (1977). Agricultural Biomass Wastes: Utilization routes. Canadian Agricultural Engineering Vol. 19 No. 2, pp. 84-87.

USDA (2012).Agricultural waste management field handbook. United States Department of Agriculture, Soil conservation Service. Accessed from <http://www.info.usda.gov/viewerFS.aspx?hid=21430> on 11/04/2012.
Wright, R. J. (1998). Executive summary (available at www.ars.usda.gov/is/np/agbyproducts/agbyexecsummary.pdf).

DESIGN, DEVELOPMENT AND PERFORMANCE EVALUATION OF AN ELECTRONICALLY AUTOMATED INCUBATOR

Ahmad, K.[1], Musa, M. J.[2]andMukhtar, Y.[3]

[1]Department of Electrical Engineering, Ahmadu Bello University, Zaria, Nigeria.kb_ahmad74@yahoo.com
[2]Heartline Farms, Beside Gombe Govt. Silos, Kwami Road, Gombe State.mmjibrin@yahoo.com
[3]Equipment Maintenance and Development Centre, Ahmadu Bello University, Zaria,ya'u_mukhtar@yahoo.com Nigeria.

ABSTRACT

This paper presents the design, development and performance evaluation of an electronically automated incubator. The dynamics of electronic circuits and their effective performance is employed to design and develop an automatic incubator with good features which include the automatic temperature and humidity control, automatic periodic turning of the eggs' tray, automatic warm air circulation system as well as digital readout of the operating temperature. Discrete and integrated circuit electronic components are used to design and implement the different segments of the system.Also an effort is made to ensure good reliability as well as cost effectiveness for the designed system to be reliable and affordable to commonman.

Keywords: Incubator, automation, Electronics

1.0 Introduction

Poultry is an important segment of modern agricultural activities that plays significant role in different aspects of human's life. This sector is very fundamental in making a country self-sufficient in terms of food supply as well as providing gainful employment to teaming population thereby reducing the level of unemployment and poverty in the society. The poultry farming in our modern society largely depends on thereliability and effectiveness of the hatching facilities. Incubators are manufactured worldwide with very high degree of efficiency in their operation. Unfortunately however, the internationally produced incubators are mostly very expensive to the extent that only rich people can afford to purchase. This serves as obstacle militating against the required meaningful development in the area. Many attempts were made by different people locally to address the problem by producing the incubators that would be affordable to common people so as to enhance effective participation in the poultry business. But most of the locally manufactured incubators suffer from one or more major problems. In some cases the incubators have to be controlled manually by regulating temperature or by turning the eggs from time to time. Whereas sometimes it lacks means of monitoring the humidity of the system and host of other short comings which make them rather bad substitute. This goes a long way making the situation more complex instead of bringing the required solution.

In trying to bring a lasting and a better solution to this problem, this work was carried out through effective design and experiments to come up with standard, reliable and affordable version of locally made incubator. The incubator is provided with adequate heating system as well as warm air circulating pump to ensure uniform temperature is maintained within the safe range and to automatically switch off the heater when the temperature goes high. Also an analog to digital converter (ADC) is used to give the temperature readout in digital form. Humidity regulation

section is incorporated where a fan is used to improve the evaporation of the water from its container also an electronic circuit that shows the relative humidity in the incubator is provided. However, an electronic timing circuit is used together with a geared bidirectional DC motor for turning the trays of the eggs after preset time.

2.0MATERIALS AND METHODS

The design and development of this automated incubator is realized using different electronic, electrical and mechanical components as well as basic measuring devices. These components include 120W AC electric heater, 12V bidirectional geared DC motor, 18V, DC air pump, IC DH7107 (ADC), IC LM 324 (comparator), thermocouple, IC CD4017 (decade counter), two NE 555 (timer IC), regulator ICs (7805, 7812, 7818 and 7905), four bridge rectifier ICs three step down transformers, four filter capacitors (2200μF), four 12V, 10A relay, seven segment display, four transistors (C945) and resistors. The measuring instruments used include digital multimeter, digital thermometer, wet and dry bulb hydrometer.

2.1 Methods

The work was carried out by designing and testing each segment of the whole system separately to evaluate its performance and finally the different sections were integrated into a single complete incubator. The methods used are as explained under the following subheadings.

2.1.1Temperature regulation section

The incubator's temperature control section is made up of different parts that include a 120W AC heater responsible for the heat generation, an 18V DC pump that circulates the heat in the cabinet for uniform temperature, thermocouple for sensing the temperature and driving the analog to digital converter for digital readout of the temperature and also triggers the relay to switch off the heater when the temperature exceeds 38^0C. The complete circuit diagram of this temperature control section is given by Figure 2.1.

The heater is located at the top inside the cabinet while the pump is connected using a pipe that goes to the bottom of the cabinet to ensure uniform temperature. The thermocouple is located close to the heater for accurate temperature sensing and the seven segment display that shows the reading of the ADC is located on the control unit outside the cabinet. As shown on the Figure 1, the ADC IC (DH 7107) needs dual rail power supply (±5) which is provided by two regulators (7805 and 7905). The temperature sensed by the thermocouple is amplified by OP – AMP LM324 then passed through buffer. The output of the buffer goes to the input of ADC and into another LM324 filter circuit which drives the relay circuit for switching off the heater in the event of excess temperature. The switching temperature is set using a variable resistor shown on the circuit. After carrying out all the necessary calculations and the required adjustments on the calculated values, the used components are given on Table 1

2.1.2 Automatic Egg's tray turning section

For proper operation of the incubator where the eggs' are hatched normally it is mandatory to have a means of turning the eggs after some specific time. The automated incubator is provided with a mechanism operated by electronic circuit that turns the eggs tray automatically after every five hours. The circuit is made up of a geared DC motor that turns through an angle of $30^0$from horizontal in both directions. The motor that drives the tray is controlled using two transistor switching circuit which is operated by a timing circuit. The timing circuit consist an astablemultivibrator made using 555 timer IC together with a decade counter. The period of the

multivibrator is made 30 minutes and this is multiplied by ten (10) by the decade counter to give the required five hours between each turning of the eggs. The complete circuit diagram of the turning system is given by Figure 2.2.The period of the astablemultivibrator is calculated using the relation;

$$T = 0.693C_6(R_{11} + R_{12})$$

The values of the resistor R_{11} and R_{12} were selected making sure that R_{11} and $R_{12} \geq 1k\Omega$ and $R_{11} + R_{12} < 3.3M\Omega$[1]. Hence using these together with the given period of 30min, the value of C_6 was evaluated.

As shown on the Figure2 the output Q_0 and Q_9 from pins 11 and 4 of the decade counter (CD4017) are connected to the switching transistors Q_3 and Q_4. When the astablemultivibrator trigger after the set 30 minutes the counter creates a delay of ten times then trigger the Q_3 to turn on the relay connected to it which turns the motor in clockwise direction. As the motor rotate for about 30^0 the gear point is grounded hence zero volt is supplied to the base of the corresponding transistor which stops the motor till another pulse is received to turn the motor is anticlockwise direction as done it the clockwise case. After carrying out all the necessary calculations and making the required decisions in selecting the components, the component used are given on Table 2.

2.1.3 Humiditycontrol and monitoring section

Humidity is another important parameter that must be managed for an incubator to perform accurately for hatching eggs. In this automated incubator an electronic circuit shown on Figure 2.3 is used for controlling and monitoring the humidity of the cabinet of the incubator. The section is made up of 12V DC electric motor which drives a fan that enhances the evaporation of water from its container to improve the humidity of the incubator interior. The humidity monitoring section uses a humidity sensor which detects the level of the humidity and delivers it to an operational amplifier connected in voltage follower configuration. A variable resistor R16 is used for regulating the sensitivity of the humidity sensor. The output of the comparator is passed to an integrated circuit LM 3915 which is versatile bar driver. It function is to sense level of an analog voltage and display its magnitude either on series of separate light emitting diodes (LED) or on a bar of LEDs. It can also drive a liquid crystal display (LCD). In this case a bar of ten LEDs is used to display the result as percentage of humidity in the incubator. The variable resistor R17 is used for adjusting the brightness of the LEDs by regulating the level of the output voltage from the comparator.

The reference voltage to the LM 3915 IC is controlled by adjusting the values of the resistors R18 andR19 as given by the equation below:

$$V_{REF} = 1.25V\left(1 + \frac{R_{18}}{R_{19}}\right) + R_{19}x\ 80\mu A$$

Whereas, the current to the LEDs is a function of the reference voltage V_{REF} and the resistor R18 as given by the equation below:

$$I_{LED} = \frac{1.25V}{R_{18}} + \frac{V_{REF}}{2.2k\Omega}$$

After executing all the necessary calculations and making the required decisions in selecting the components, the component used are given on Table 3.

2.1.4 General control unit

The various circuits discussed above that control different sections of the incubator are constructed on the veroboard and then encased in a general control unit made in form of rectangular box using a metal. All the indicators that show different parameters of the incubator are mounted on this control unit. However, the wires that supply power to the system and those connected to the sensors are connected between the control unit and the appropriate points. Figure 4 shows the sketch of the control unit.

3.0 RESULTS AND DISCUSSION

The automated incubator after been constructed as explain above by constructing the different sub units and integrating them to give the whole system has to be tested to actually evaluate its performance practically and compare them with the desired performance from the design specifications. In this regard the incubator was loaded with two types of eggs; the quail eggs and chicken eggs. The estimated capacity of the incubator is about 210 chicken eggs. In this testing period 110 quail eggs and 25 chicken eggs were placed into the incubator on March 18, 2010. The hatching of the quail eggs begins sixteen days later on April 3, 2010 where a total of 97 quail eggs were hatched successfully and on April 5, 2010 22out of the 25 chicken eggs were hatched successfully. This means that 88.2% of the quail eggs were hatched and 88% of the chicken eggs were hatched. An overall percentage success is 88.14%. During these days the readings of the temperature and the humidity were taken on daily basis to really monitor the operating condition of the incubator. The readings of the temperature were also taken using standard digital thermometer to validate the readings given by the designed one. These readings are shown on the table 4.

3.1 Sketch of the incubator casing

The incubator casing is made using a wood. The interior is sealed using an aluminum sheet to enhance the retention of the internal temperature. It is provided with two doors each with a glass window. The motor and the mechanism for turning the eggs trays are located on one side of the incubator. The figure 5 shows the incubator casing with basic parts illustrated.

4.0 CONCLUSION

The electronically automated incubator was found functioning properly according to the design requirements and its efficiency from the result of first incubation was above 88%. All the important operating parameters like temperature and humidity remains within the desired limit. The cost of construction is expected to be very attractive especially in the event of mass production. This work is therefore, going to contribute greatly in enhancing the rapid growth of poultry farming in the country.

REFERENCES

Boylestad R. L. and Nashelsky L. " Electronic Devices and Circuit Theory". Prentice – Hall of India 2004.

Bozic S. and Parsons J. D., "Electronic and Switching Circuits" Edward Amold Ltd 1975."E. C. G. Master Replacement guide" Philips Consumer Electronics Company, 19th edition 2001.

Freee electronics tutorials.www.wikipedia.com

Link J. D. " Hand book of simplified state Circuit design", McGraw Hills, New York, 1996.

Michael J. "Application and design with Integrated Circuit" Burma Press LTD, New Delhi India 2000.

"Motorola Semiconductors Data Manual".Volume I, First Edition 1983.

Parkers J. "New Design Ideas with Integrated Circuits" IEE Electronics and Communication Engineering Journal, PP 21 – 27 Vol. 133 October 2001.

Reign, H. J., "Theory and Applications of active devices", Van Morse Press, New York, 1987.

savant C. J., Roden M. S. and Carpenter G. "Electronic design" Benjamin/Cumming publishing Co. 1981.

Theraja B. L and Theraja A. K. "Electrical Thechnology" New Edition with electronics, Bengel Press LTD, New Delhi India 2003.

Williams G. E. "Practical Transistor Circuit and analysis", McGraw – Hill Book Co. London 1970.

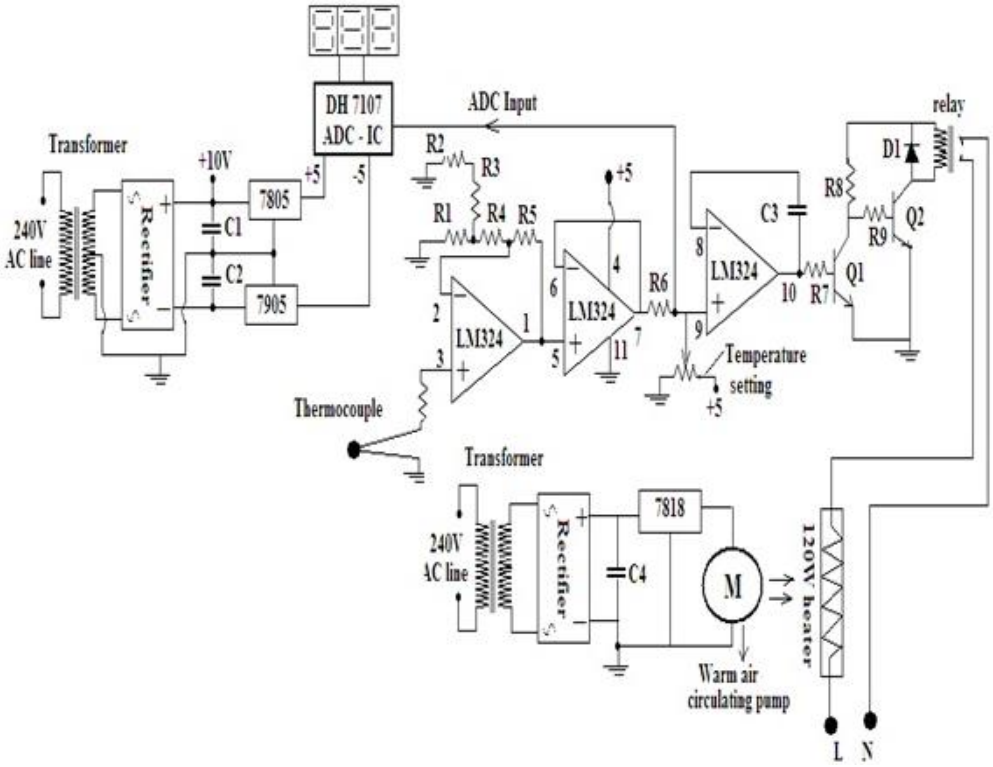


Figure 1: Circuit diagram of the temperature control section

Table 1: components of the temperature control unit

Serial No.	Component	Value / part number	Quantity
1	Comparator IC	LM324	1
2	Regulator IC	7805 , 7818, 7905	3
3	Transformer	240V / 10V, 240V / 18V	2
4	Rectifier IC		2
5	ADC IC	DH7107	1
6	Seven segment display		1
7	Filter capacitors	2200µF – 3, 220pF	4
8	Thermocouple		1
9	Electric Heater	120W AC	1
10	DC Motor (pump)	18V	1
11	Transistors Q_1, Q_2	C945	2
12	Diode	1N4007	1
13	Resistors R_1 - R_9	10k, 820Ω, 10k, 18k, 220k, 470Ω, 10k, 50k, 22k respectively	9
14	Relay	12V, 10A	1

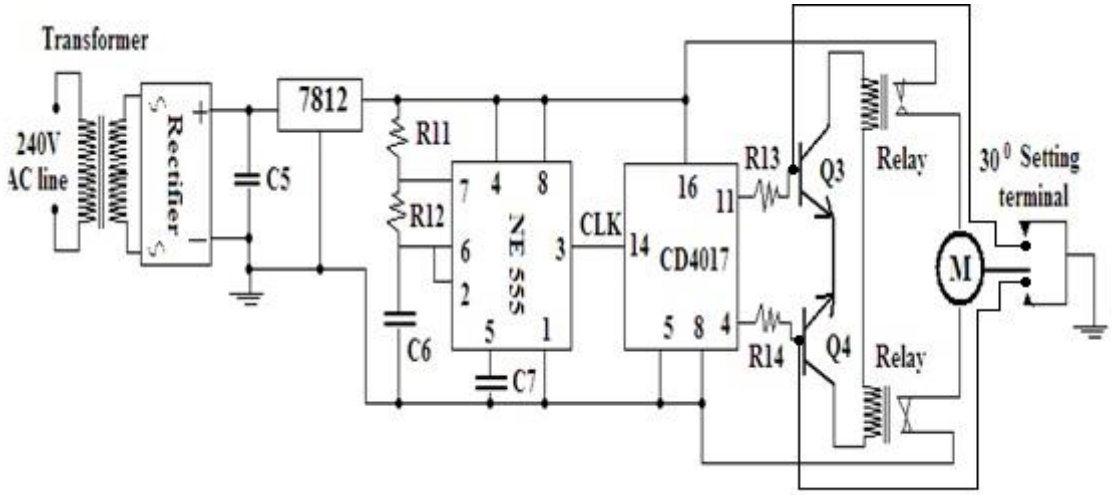


Figure 2: Eggs tray turning circuit

Table 2: components of the Automatic Egg's tray turning section

Serial No.	**Component**	**Value / part number**	**Quantity**
1	Timer IC	NE 555	1
2	Decade counter IC	CD4017	1
3	Transformer	240V / 12V	1
4	Rectifier IC		1
5	Regulator IC	7812	1
6	Capacitors C5 – C7	2200μF , 1000μ F.1μF	3
7	Geared DC Motor	12V	1
8	Transistors Q3, Q4	C945	2
9	Resistors R_{11} – R_{14}	1.3MΩ, 1.3MΩ 4.7kΩ, 4.7kΩ, respectively	4
10	Relay	12V, 10A	2

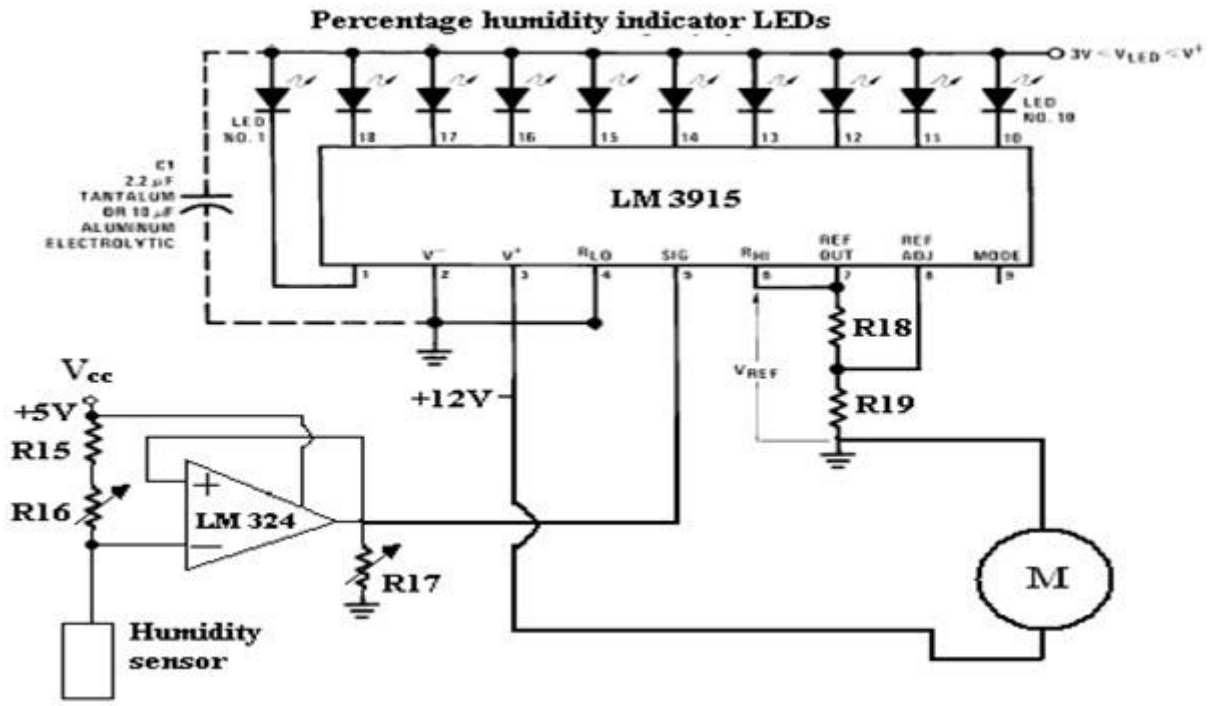


Figure 3: Humidity control section

Table 3: Components of the humidity monitoring and control section

Serial No.	Component	Value / part number	Quantity
1	Display driver IC	LM 3915	1
2	Comparator IC	LM 324	1
3	Humidity sensor		1
4	Electric motor	12V DC	1
5	LED bar display		1
6	Noise filter capacitor	2.2µF	1
7	Resistors $R_{15} - R_{19}$	1kΩ, 10kΩ, 500Ω, 1.24kΩ, 8kΩ	5

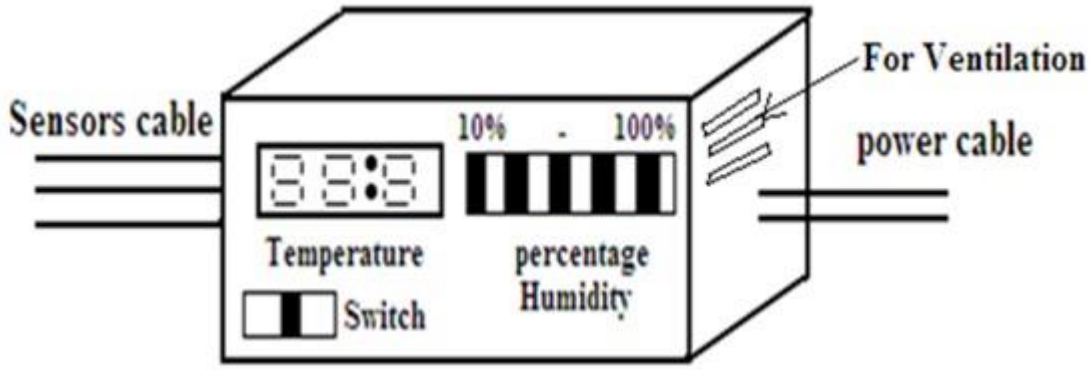


Figure 4: Central control unit

Table 3.1 Temperature and humidity readings for nineteen days

Day	Date	Temperature reading of ADC Display	Temperature of digital thermometer	Relative humidity	Number of Days
THUR	18/03/2010	37.0	37.1	60	0
FRI	19/03/2010	37.0	37.0	60	1
SAT	20/03/2010	36.8	37.0	60	2
SUN	21/03/2010	36.6	36.8	60	3
MON	22/03/2010	36.6	36.5	60	4
TUE	23/03/2010	36.4	36.8	60	5
WED	24/03/2010	37.5	37.2	60	6
THUR	25/03/2010	38.0	37.8	60	7
FRI	26/03/2010	37.0	37.1	60	8
SAT	27/03/2010	37.0	37.2	70	9
SUN	28/03/2010	37.0	37.2	70	10
MON	29/03/2010	36.5	37.0	60	11
TUE	30/03/2010	37.0	37.0	70	12
WED	31/03/2010	37.0	37.1	70	13
THUR	01/04/2010	37.0	37.0	70	14
FRI	02/04/2010	36.8	37.0	70	15
SAT	03/04/2010	36.6	36.8	70	16
SUN	04/04/2010	37.0	37.1	70	17
MON	05/04/2010	37.2	37.3	70	18

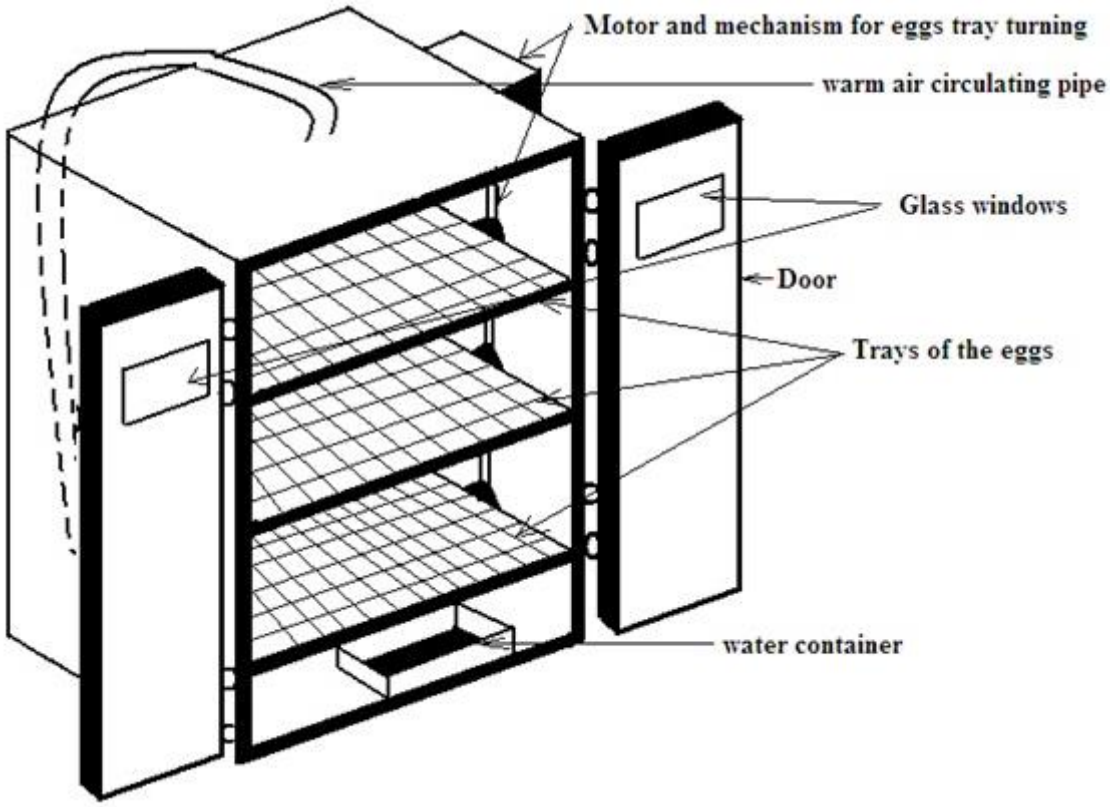


Figure 5: Complete incubator casing

ASSESMENT OF WEAR ELEMENTS IN FOOD PRODUCT BY DRY MILLING USING ATOMIC ABSORPTION SPECTROSCOPY TECHNIQUE

Ahmad H. I.[1], Jahun, B. G.[2] and Abubakar, S. M. [2]

[1]Dept of Agricultural EngineeringBayeroUniversity, Kano.
[2]Dept of Agric and Bio-Resources Engineering, AbubakarTafawaBalewaUniversity, Bauchi.bgjahun@yahoo.com

ABSTRACT

This work aimed at determining wear elements in food materials produced through dry milling was conducted in Yelwa area of Bauchi metropolitan. The study selected milling shops and collected samples for maize and guinea corn. The food samples were prepared through ashing and aquaregia digestion before quantifying concentrations using atomic absorption spectroscopy (AAS). Results obtained were compared with set standardlevels for human and animal consumption. Out of ten elements (Chromium, copper, iron, manganese, magnesium, zinc, lead, cadmium nickel and calcium) found present in the food materials, only were above the safe levels.

Key words: Wear elements, dry milling, safe consumption levels, and Atomic absorption spectroscopy.

1.0 Introduction

Dry milling process involves direct contact of food materials with component members of milling machine which over time experience wear due to friction between machine members and food material being processed. These wear materials are dissolved into the food products which in turn have adverse effects on human beings and animals if consumed with the food materials (Taylor and Felix, 2005).

The standard regulatory body for food and drugs, have set safe levels for these wear element in food which when these levels are exceeded could have adverse effects on human and animals health after consumption (WHO, 2001).

The determination of trace elements and contaminants in complex matrices, such as food, often require intensive sample preparation and /or extractor regimes prior to instrumental analysis.

The traditional techniques for sample analysis are time consuming and require large amounts of reagents, which are expensive, generate hazardous waste, and might contaminate the sample. Advances in sample preparation over the last few decades have been propelled by the advance of microwave-assisted acid as reported by Perkin-Elmer, 1973.

Automated procedures are generally even better than manual methods and will also decrease the staff time spent out on sample preparation, which is often the bottleneck in analytical laboratories (Taylor and Felix, 2005).

Atomic Absorption Spectroscopy (AAS) is an important analytical technique based upon the absorption of radiation by free atoms.Virtually all metallic elements can be directly detected with

excellent accuracy, precise quantization and very sensitive detection limits. These techniques can also be used indirectly to measure the amounts of some non-metallic elements (Taylor and Felix, 2005).

Considering that wear elements are daily taken up by people in food rations, effective control measures have to be employed and thus the aim of this study is to:
Determine the types and level of wear elements in dry milling processes, and compare such concentrations with safe standard levels recommended by World Health Organization (WHO).

MATERIALS AND METHODS

Materials and Equipment:

The following food materials and reagents/equipment were used for the experiment,

i. Food samples used include
   a. Maize flour.
   b. Guinea corn (*dawa)* flour.
ii. 150ml Nitric acid (HNO_3) was used during the digestion of food sample.
iii. 1000ml Round bottom flask was used for carrying digestion samples to the AAS.
iv. 1500g Digital Weighing Balance was used for weighing the food samples.
v. Atomic Absorption Spectroscopy equipment (AAS) model 210 VGP of buck scientific type was used to test the samples collected.

Methodology

The food samples (maize and *dawa)* were collected from dry grinding-milling shops within Yelwa area of Bauchi metropolitan (Abubakar, 2011). The AAS machine was used to determine the wear element present in the food samples after sample preparation using dry ashing.

One gram of each food samplesfrom the milling machine were weighed using digital weighing balance and poured into a labeled container. The resulting food sample was dissolved in a solvent of 50ml Nitric acid (HNO_3).The food sample were injected directly to the AAS equipments, where it was heated to vaporize and atomize the food sample, the absorption of radiation were measured at specific wavelength corresponding to the element contain in the sample. The AAS technique is as outline by Ahmad et al.; (2012). Atomic Absorption equipment was divided into seven fundamental groups that have two major functions, generating atomic signal and signal processing. The prepared food sample was injected into a cathode lamp which has a stable light source necessary to emit the sharp characteristics spectrum of the element. The second stage is the atom cells which nebulize sample solution into a fine aerosol solution, and dissociation of the analyte elements into free gaseous ground state form. As the sample passes through the beam of light into the monochrometer, the monochrometer isolate the specific spectrum line emitted by the light source through spectral dispersion, and focuses it upon a photomultiplier detector which convert the light signal into an electrical signal. The electrical signal processed readout and results printed.

The types and the level of elements present during laboratory sample analysis were determined and tabulated.

The relationship between the element present and depositional level were also plotted in graph form by using Microsoft Excel software. The results were compared with World Health Organization standard of minimum safe content of wear elements in the sample.

RESULTS AND DISCUSSION

The results obtained from laboratory analysis are presented in Tables 1 and 2.The results show that **Magnesium** (Mg) and **Calcium** (Ca) element have high depositional levels of 113.99mg/kg and 83.92mg/kg respectively in maize samples and 129.75mg/kg (Mg) and 94.01mg/kg (Ca) in Guinea corn samples. . The Standard safe level content is 70mg/kg to 100mg/kg as recommended by WHO (1993).When compared with experimental results show that the element was high for body to accumulate. The consumption of these two elements in large quantity will be detrimental to the natural healing function(Ahmad et al.; 2012). The depositional levels of Magnesium and Calcium in both samples were high because most of the cereal crops have high Magnesium and Calcium in their initial stage of growth (Ahmad et al.; 2012).

Zinc (Zn) element present has a depositional level of 6.048mg/kg in Maize samples and 7.110mg/kg in Guinea corn food samples. Recommended diet allowance of Zinc is not more than 9mg/kg as set by World Health Organization (WHO) safe level recommended. By comparing the two results it shows that the level of Zinc is within safe level.

Iron (Fe) element present has a depositional level of 5.932mg/kg in Maize flour samples and 7.644mg/kg in Guinea Corn samples. The standard recommended level of iron as set by Provisional Tolerable Daily Intake (PTDI) is 5.5mg/kg. By comparing experimental result and safe standard by WHO shows that iron present are high so there was an excess Iron in the sample due to wear of plates during milling. The excess amount of iron in food product sample can cause disease such as sickle cell anemia, and blood cancer.

Copper (Cu) element present has a depositional level of 3.684mg/kg in Maize flour sample and 5.136mg/kg in Guinea Corn sample. The standard recommended **s**afe level of Copper was 2.7mg/kg as set by World Health Organization (WHO). When comparing the experimental result shows that the amount of copper present was high than the recommended safe levels. The Copper was heavy metals which have a high metallic weight and density. Copper in small amounts, are necessary for proper metabolism to occur which was normally occurred at low concentration of copper. But at high concentration, copper was become a toxic to human, there was a tendency of cancer.

Manganese (Mn) Present has a depositional level of 1.589mg/kg in Maize sample and 2.341mg/kg in maize flour sample. The recommended safe level of manganese was 2.5mg/kg as set by World Health Organization WHO (1993). When compared with laboratory the experimental result with WHO standard manganese was within the range.

Chromium (Cr) element present has a depositional level of 0.043mg/kg in maize flour sample and 0.018mg/kg in Guinea corn flour sample. The standard safe level of Chromium was 0.01mg/kg as set by World Health Organization WHO, 1993 and therefore within the safe standard level.

Lead (Pb) element present from experimental result shows that lead has a depositional level of 0.674mg/kg for Maize flour sample and 0.853mg/kg in Guinea corn flour sample. Environmental

Protection Agency (EPA) Safe limit of lead in food was 0.5mg/kg. Its limit in drinking water was 0.4mg/kg. The recommended safe content of lead in our food as set by World Health Organization was 0.124mg/kg. Therefore from the experiment result the level of lead from both two samples were high which can cause serious effect to human health. Leads affects the red blood cells (cause anemia) and causes damage to organs including the liver, kidneys, and heart and male gonads as well as causes effects to the immune system.

Nickel (Ni) element has a depositional level of 0.00mg/kg in maize flour sample and 0.00mg/kg in Guinea corn sample from experimental result, the two food samples were free from Nickel which has 0.00mg/kg level of Nickel. The safe standard level of Nickel according to WHO (1993) was 0.04mg/kg.

CONCLUSION

From the conduct of this study, it is hereby concluded that:

i) Many elements were present in food samples prepared by dry milling in Bauchi.
ii) The elements with higher concentrations than safe standard levels are (Magnesium,Iron, Copper, and Lead).

RECOMMENDATIONS

This study could be more useful if the merit and demerits of each element are available to the researcher for proper discussion of the results. Therefore, it is recommended that extensive literature review be done for further work on such elements and the constituents/composition of the milling machines especially those coming in contact with the food materials being processed.This will allow for distinguishing which elements are coming from wear process or inherent within the crop due to fertilization or soil environment. Also more food items consumed in the area should be investigated. The crops need to be tested prior to the milling process to know the levels of trace elements.

REFERENCES

Ahmad H.I., M.L. Sulaiman, D. Ahmad and D.D. Yusuf (2012): Determination of Wear Elements in SteyrUrsus Tractorlubricating oil using AtomicAbsorption Spectroscopy (AAS). Paper accepted for presentation at an International Conference on Agricultural and Food Engineering for Life CAFEi 2012 Putraja, Malaysia.

Perkin-Elmer(1973): Analytical Methods for Absorption Spectrophotometry; Norwalk, CT, New York. Pp. 15-25.

Sperling, M. and Welz, B. (1999): Atomic Absorption Spectrometry, Wiley-VCH, Weinheim, Germany, ISBN 3-527-28571-7. Pp. 80, 92-101

Taylor, S.A. and Felix, B. (2005): Method of Analysis of Food Component and Additives Journal of Food Science. I. Pp. 40-43.

WHO (1993): Hand book of Provisional Tolerable Daily Intake, World Health Organization, and Geneva. Pp. 23-27.

WHO (2001): Journal of International Programme for Chemical Safety No. 22: World Health Organization, Geneva. Pp. 22-24.

Table 1:Type and concentration of wear elements found in Maize flour samples.

Wear Element Present	**Concentration mg/kg**	**Wear Element Present**	**Concentration mg/kg**
Cr	0.043	Zn	6.048
Cu	3.684	Pb	0.674
Fe	5.932	Cd	0.002
Mn	1.589	Ni	ND
Mg	113.99	Ca	83.92

Table 2: The level or concentration of wear elements in Guinea Corn flour Samples.

Wear Element Present	**Concentration mg/kg**	**Wear Element Present**	**Concentration mg/kg**
Cr	0.018	Zn	7.110
Cu	5.136	Pb	0.853
Fe	7.644	Cd	0.003
Mn	2.341	Ni	ND
Mg	129.75	Ca	94.01

DEVELOPMENT AND PERFORMANCE EVALUATION OF PACKAGING METHODSFOR FRESH TOMATO IN BORNO STATE, A SEMI ARID ENVIRONMENT

Dzivama, A.U.[1], Lawal, A. A.[1]. and Saidu,M.J.[2]

[1]Department of Agricultural and Environmental Resources Engineering, Faculty of Engineering,University of Maiduguri, Maiduguri, Borno State, Nigeria.audzivama_umar@yahoo.com

[2]Department of Agricultural and Bio-Environmental Engineering,

College of Agriculture Jalingo.

ABSTRACT

The objective of this study was to develop and evaluate the performance efficiency of improved packages for transportation of tomatoes. In pursuance of the objectives, two improved packages with the same capacity of 36kg, but different shapes were developed. Factors considered in design and developments of the packages were: capacity, volume, depth, shape and strength; availability of material, ease of construction; and stacking density of the packages for transportation. The performances of the packages were evaluated by transporting tomatoes from Baga to Maiduguri, and measuring the percentage of mechanical damage and severity of mechanical damage sustained in each package. Cost analysis and economic return for the use of the different packages were also carried. The result of the performance evaluation showed that the percentages of mechanical damage of tomatoes obtained in the local package (LP), package base on angle of repose (P_{BAR}),and rectangular package (RP) were 47%, 23.01% and 15.33% respectively. The degree of severity of mechanical damage in local package was highest followed by P_{BAR} and RP packages respectively. The benefit gain in monetary term for transporting tomatoes in P_{BAR}, and RP packages instead of local package were 16,956 and ₦ 44,587 per trip. RP package had the lowest amount of return on investment, while P_{BAR} had the highest value. Tomatoes in RP package had the lowest mechanical damage, highest profit gain per trip and lowest amount of return on investment, and therefore, the most suitable package for transportation of tomatoes.

Keywords: local package, improved package, tomato, mechanical damage, Borno state

1. Introduction

Tomato (*lycopersiconesculentum*) is one of the most important vegetables worldwide (Cox, 2000). In Nigeria, as in many other countries, it is consumed fresh, used for soup preparation, and processed into various products such as tomato puree and paste. Tomato is also vital to human nutrition and health. It is a good source of *lycopene* and vitamin A and C (Cox, 2000; Kasmire and Kader, 1978). Fresh tomato has high moisture content (70-90%), soft tissue and high rate of physiological activities (Wills et al., 1981). These make tomato very perishable, more especially as a result of mechanical damage, which may occur at any stage of post-harvest handling.

Mechanical damage is reported as one of the major causes of post-harvest losses of fresh tomatoes (Panhwar, 2006; FAO, 1989; Kader, 1983; Kasmire and Kader, 1978). Mechanical damage results from a number of causes, including poor handling practices, inadequate

packaging, bad stacking, poor road conditions, and bad driving practice (Hilton, 1994). Reduction of mechanical damage requires careful handling and use of appropriate technology along the supply chain. Adoption of suitable packaging methods can significantly reduce mechanical damage during post-harvest handling and transportation.

Packaging methods for fruits and vegetables in developing countries have remained traditional, using bamboo baskets, cartons, kerosene tin and calabash among others (Raji and Oriola, 2007; Osunde et al., 2004). These packages are either not strong enough to prevent mechanical injuries or themselves impact mechanical injuries on the fruit. Thus, most losses of fruits and vegetables which occur in transit are due to poor and ineffective packaging materials.

Mechanical loss which accounts for more than 30% will continue if alternative and adequate packaging method is not developed for the transportation of vegetables like tomatoes. Attempts have been made to improve strength and cushioning effect of the local packages by inserting dividers and linings in cartons and local baskets. These efforts only prove to be effective on short term basis. Local packages failed to withstand the rigors during long distance transportation. Thus the need to develop an improved package for vegetables such as tomatoes with a view to reduce losses due to mechanical damage during transportation.The objectives of this study were to: design and develop suitable package using local material for transportation of tomatoes and evaluate the performance of the new package in terms of reduction of mechanical damage and economic benefit of adopting the new packages.

2. MATERIALS AND METHODS

2.1 Study Area

The study area for the field experiment were Maiduguri ($11^{o}51'$N, $13^{o}08'$E) and Baga ($12^{o}31'$N, $13^{o}50'$E), which are located in north eastern part of Nigeria, a semi arid environment. The study was conducted during the period of February to May 2011, a season for tomatoes in the area.

2.2 Development of Improved Package

2.2.1 Design Consideration

The following factors were considered in the design of the package:

i. Capacity, depth and volume of the package
ii. Shape of the package

The capacity of the package was chosen to be 36kg which reflects the average capacity of local basket used by farmers for transportation of tomato (Idah et al. 1999; Dzivama and Lawal 2009). The volume of the package was obtained taking into consideration the capacity of the package and depth of the package to which tomatoes at bottom layer will sustain minimum injury. The depth of the package was calculated following the procedure employed by Studman and Gayer (2002) and Ostrem and Godshall (1979):

$$L_{avgbl} = \frac{W_t}{N_{tbl}} \quad (1)$$

$$L_{maxbl} = L_{avgbl} \times 3.5 \quad (2)$$

$$L_{dynbl} = L_{avgbl} \times 2 \quad (3)$$

whereL_{avgbl}, $L_{maxbl}$and L_{dynbl} are average, maximum and dynamic loads respectively each tomato at bottom layer will sustained, W_t is total weight of tomatoes in package, and $N_{tbl}$is number of tomatoes at bottom layer.

The numbers of tomatoes at bottom layer were varied by changing the bottom size of the package, to obtain maximum load, L_{maxbl}that corresponds to tomato average bruise threshold load. This load was then used to calculate the optimum depth for the package.

Factors considered in developing the shape of the package are angle of repose of tomatoes, loading space and capacity of transportation truck. Based on these factors two packages, namely package based on angle of repose and rectangular package, with different shapes were proposed and developed.

2.2.2 Choice of Materials

The following factors were considered in the choice of materials for the construction of the package: strength, availability, cost and ease of construction. Based on the above factors; wooden materials were chosen for the construction of the package. Lumber was used as frame members for the package while plywood was used for the side, front and bottom panels. The sizes and strength of the materials were determined from stress-strain analysis of the static and dynamic loads expected during handling (loading and transportation).

2.2.3 Description of the Packages

The packages as depicted in Figures 1 and 2, are composed of the frames (1 -3), panels (4 -6) and fastenings (7). The frames (1 – 3) give the packages there shape and structural strength to sustain stacking and impact loads during transportation. Frames are made from wooden lumber. The side, front and bottom panels are made of plywood which increased the strength of the package and keep its contents intact. Fastenings (7) are nails of various sizes, which are used for joining wooden parts together.

2.3 Performance Evaluation of the Packages

1. Reduction in the level of mechanical damage obtained by the packages
2. Economic analysis for transportation of tomatoes in the packages

2.3.1 Experimental design and procedure

Completely Randomized Design was used to obtain the result of mechanical damage sustained in the three packaging methods. Three replications were made for each packaging method. For each replication five packages of tomatoes were chosen at random and marked for evaluation after transit. Thus, 3 packaging methods × 3 replications × 5 packages = tomatoes from 45 packages were evaluated for mechanical damage.

To evaluate the performances of the packages the following experiments were conducted. Fresh tomato fruit (*romavf*) were picked and packaged into the various packages at farm. The packages were loaded onto truck and arranged as shown in Plates 1 to 3. At farm gate, five packages from each trip were randomly selected and labeled and the quality of their content (tomatoes) was considered as no mechanical damage. A conventional pick-up van with loading space dimensions

2400mm length, 1600mm width and 800mm height and capacity of 2500kg was used for the experiment. The vehicle was then driven at a normal speed of 30km/h on untarred/rough road and up to 60- 80km/h on tarred road from Baga to Maiduguri. On arrival at Maiduguri, 60 tomato fruits from each selected packages were randomly picked from top, middle and bottom layers (20 from each layer) and packaged in a perforated polyethylene bag. These samples were then kept under room temperature for two days to allow for latent damage to be visible and suitable for mechanical damage evaluation. The trip was replicated three times for each packaging method.

2.3.2 Statistical Analysis

Analysis of variance was carried out as described by Gomez and Gomez (1983). The analysis of variance was specifically used in this study to examine the variation in the results of the performance of packages. Statistix version 9 software was used for the analysis on a personal computer.

2.4 Economic Analysis

The following indicators were used to evaluate the economic loss or gain by using the various packages: Cost, benefit and return on investment. Cost analysis involves the cost of transporting unit weight of commodity in particular packaging method (Rapusas and Rolle, 2009). Benefit analysis involves the net profit per trip of transporting a commodity in a particular packaging method.

3. RESULTS AND DISCUSSION

3.1 Effect of Packaging on Mechanical Damage per Package (D_y%)

The results of the mechanical damage sustained by tomatoes in the improved packages compared to the local package are presented in Table 1. The result of the analysis of variance shows that the effect of packaging on mechanical damage per package is significant at 1%. This means that improved packages significantly reduce the level of mechanical damage sustained by tomatoes during transportation. The mean separation result also indicated that mechanical damage per package of local package is significantly greater than mean mechanical damage per package of P_{BAR} and RP packages. Mechanical damage per package of RP package is significantly lower than the value of P_{BAR} package. This result shows that RP package is the best in terms of reduction of mechanical damage per package.

3.2 Effect of Packaging on Mechanical Damage Index

The percentage of the damage indices sustained by tomatoes in the various packages is presented in Figure 3. Figure 3shows that local package had the highest percentage of tomatoes with extreme, severe, and slight mechanical damage. RP package had the lowest percentage of extreme, severe, and slight mechanical damage followed P_{BAR} package. This result indicates that severity of mechanical damage to tomatoes decreased from local package to P_{BAR} and RP package respectively.

3.3 Economic Analysis

The cost analysis for packaging and transporting unit kilogram of tomatoes in local and improved packages are presented in Table 2. The unit cost of packaging tomatoes in local package was the

lowest, ₦ 16.1, while in P_{BAR} and RP packages were at ₦ 19.6 and ₦18.06 respectively. The profit analysis of handling and transporting tomatoes in local and improved packaging methods per trip are given in Table 2. It can be noted that net profit per trip for local package, P_{BAR} and RP packages were ₦ 71,604, ₦ 88,560 and ₦ 116,191 respectively. RP package had the highest net profit while P_{BAR} package had the lowest profit. The benefits gained per trip by adopting improved packages were ₦ 16,956 and ₦ 44,587 for P_{BAR}, and RP packages respectively.Table 2 also shows the number of usage of improved package to cover the initial cost of investment. The initial costs of investment of P_{BAR}, and RP packages were recovered after 3 and 2 usages respectively.

4. CONCLUSION

The following conclusions were made for the study:

1. The improved packages performed much better than the local package, with a difference of at least 20.2% and up to 31.7% reduction in mechanical damage per package.
2. The level of severity of mechanical damage was reduced by using improved packages compared to local package.
3. There was high initial cost in the use of the improved packages, which was offset by economic return in terms of lower mechanical damage. These translate to economic gain for several trips.
4. RP package is the best packaging method with the least percentage of mechanical damage of 15.33% and highest economic return.

In view of the above conclusions, the following are recommended for transportation of tomatoes in this region and for further studies with a view to improving the performance of the packages in terms of the reduction in mechanical damage.

1. RP and P_{LP} packages are recommended for transporting tomatoes in this region.
2. RP and P_{LP} packages should be tested for transporting other agricultural products with a view of extending their applicability.
3. Laboratory investigation on parameters responsible for mechanical damage should be conducted with a view of identifying them to improve the design of the RP and P_{LP} packages.
4. Further investigation by testing the RP and P_{LP} packages using cushioning material could be investigated.

REFERENCES

Cox, S. 2000. I say tomayto, you say omahto.http://www.landscapeimagery.com/tomato.html

Dzivama, A.U., and Lawal, A.A. (2009). Assessment of Tomato Losses in Baga a Semi AridEnvironment, African Journal of Agricultural Research and Development, 2 (2): 71-76

FAO (1989). Prevention of post-harvest food losses: fruits, vegetables and root crops,a training manual. FAO Training Series No. 17/2.FAO, Rome, Italy, 157 p.

Gomez, K.A. and Gomez, A.A. (1983).Statistical Procedure for Agricultural Research.AnInternational Rice Book. A Willey interscience publication, New York

Hilton, D.J. (1984). Impact and Vibration Damage to Fruit during Handling and Transportation.Proceedings of the post-harvest handling of tropical fruits. Champ B. R., Highley E. and Johnson G. I., (Eds). Australian Center for International Agricultural Research 116-26.http://aciar.gov.au/file/node/2248/pdf

Idah, P.A., Adeoti, J.S. and Oje, K. (1999).Evaluation of Effects of Handling Devices on somePhysical and Mechanical Properties of Fresh Tomatoes. Journal of Nigerian AssociationTeachers Technology 3(1): 174-182

Kader, A.A., (1983). Post-harvest Quality Maintenance of Fruits and Vegetables in Developing countries. P. 455-470. Lieberman M. (ed.), Post-harvest Physiology and Crop Preservation, Plenum Publishing Corporation, New York.

Kasmire, R.F. and Kader,A.A. (1978). Handling Tomatoes at Wholesale and Retail:a Guide for Better Quality and Greater Profits. Outlook, 5(3): 5-12.

Ostrem, F.E. and Godshall, W.D. (1979). An Assessment of the Common Carrier ShippingEnvironment: General Technical Report FPL22. Forest Products Laboratory, ForestService, U.S. Department of Agriculture, Madison, Wis 19

Osunde, Z.D., Oladapo, M.A. and Adekola K. (2004). Survey of Packaging and TransportationMethods for Fruits and Vegetables in Central Nigeria. African Journal of Development Studies, 4(1- 2): 106-112.

Panhwar, F. (2006).post-harvest technology of fruits and vegetables. ECO Service International.

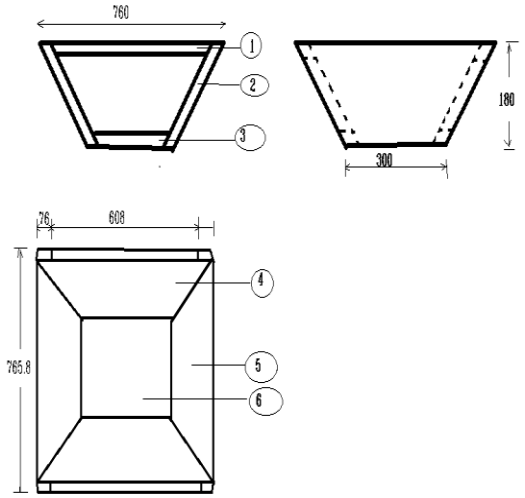
Raji O. A. and Oriola O. K. (2007).Packaging and Handling Methods as Sources of MechanicalDamage in Tomatoes in Transit. Journal of Engineering and Applied Sciences, 2(9):1450-1454.

Rapusas R. S. and Rolle R. S. (2009). Management of Reusable Plastic Crates in Fresh ProduceSupply Chain: A technical guide. FAO, Rome, Italy.

Studman, C.J. and Geyer, M. (2002).Modeling the Load Distribution of Stacked Apples ando ther Spherical Objects.Biosystems Engineering, 82(1): 65-72http://www.idealibrary.com

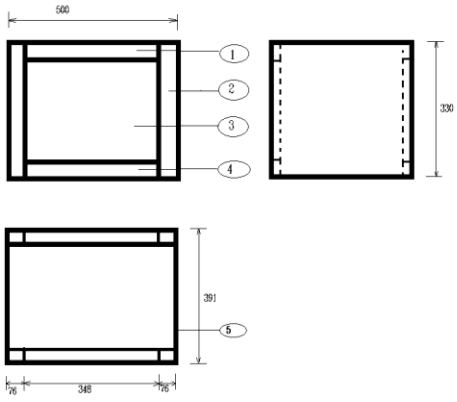
Wills, R.H.H.; Lee, T.H.; Graham, D.; McGlasson, W.B. and Hall, E.G. (1981).Post harvest: an introduction to the physiology and handling of fruits and vegetables. Granada Pub.Co.

PARTLIST



S no.	Part	Material	Quantity	Dimension
1.	Upper horizontal frame member	Lumber	2	76 by 25.4 mm Length 700mm
2.	Vertical frame members	Lumber	4	76 by 25.4 mm Length 358mm
3.	bottom horizontal frame member	lumber	2	76 by 25.4 mm Length 147.6mm
4.	panel sheath	12.7mm plywood	2	608mm by 330mm
5.	side sheath	12.7mm plywood	2	766mm by 391mm
6.	floorboard	12.7mm plywood	1	391mm by 330mm
	Projection Scale: 1:10mm	Third angle Dim. mm		

Figure1: Third angle projection of package developed based on angle of repose, P_{BAR}



S no.	Part	Material	Quantity	Dimension
1.	Upper horizontal frame member	Lumber	2	76 by 25.4 mm Length 348mm
2.	Vertical frame members	Lumber	4	76 by 25.4 mm Length 330mm
3.	Panel sheath	12.7 mm plywood	2	500mm by 330mm
4.	Lower horizontal	Lumber	2	76 by 25.4 mm Length 348mm
5.	frame member floorboard	12.7 mm plywood	1	500mm by 391mm
6.	side sheath	12.7 mm plywood	1	391mm by 330mm
	Projection Scale: 1:10mm	Third angle Dim. mm		

Figure 2: Third angle projection of rectangular package, RP.



Plate 1: Tomatoes packed in Bamboo basket (LP) and loaded on truck



Plate 2: Tomatoes packed in P_{LP} package and loaded on truck



Plate 3: Tomatoes packed in RP package and loaded on truck

Table 1: Effect of packaging method on average mechanical damage

Type of package	**Average mechanical damage**	**Percentage of type of mechanical injury**		
	(Dy%)	Bruise	Crack	Cut
Local package	47a	78.1	19.5	2.4
P_{BAR} package	23.01b	91.4	4.4	4.2
RP package	15.33c	99.5	0.5	-

1% probability level ($p<0.000$) and F-ratio = 191.47; Values with the same alphabet letter are not significantly different

Table 2: Economic performance of transporting tomatoes in the various packages

	Packaging method		
	Local package	**P_{BAR} package**	**RP package**
Cost of packaging unit kg of tomatoes (₦)	16.1	19.6	18.06
Profit of packaging per trip (₦)	71,604	88,560	116,191
Benefit (₦)		16,956	44,587
Return on investment		3 times	2 times

Assumption/conditions:
Transport vehicle: Toyota pick-up van (2400mm x 1600mm x 800mm)
Route: Baga to Maiduguri
2 layers of package (2 packages per column)

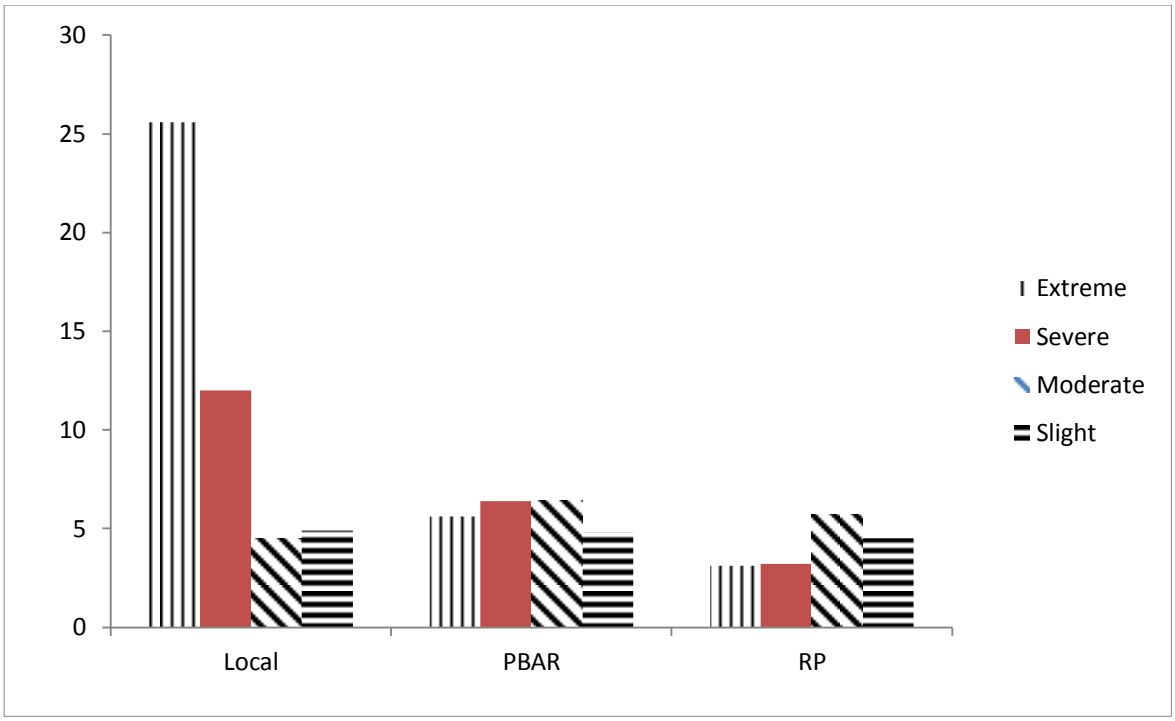


Figure3: Percentages of Mechanical Damage Indices in Various Packaging Methods

MOISTURE SORPTION OF DRIED TOMATO FLAKES AT DIFFERENT TEMPERATURES

S. K. Shittu[1], A.M.I. El-Okene[2], M.Isiaka[2] and M.L. Suleiman [2]

[1]Department of Agricultural Engineering, Bayero University Kano, Nigeria. sarafadeenshittu@yahoo.com
[2]Department of Agricultural Engineering, Ahmadu Bello University Zaria, Nigeria.

ABSTRACT

Relationship between water activity and sorption equilibrium moisture content of dried tomato flakes were determined gravimetrically using different concentrations of aqueous solution of sulfuric acid. The solutions were prepared to give relative humidity range 0.1-0.8. The study was carried out at three levels of temperature 10^{o}C, 30^{o}C and 45^{o}C. In each of these temperatures, data on the equilibrium moisture contents obtained with their corresponding water activitywere fitted to five isotherms models namely: Henderson, Halsey, Smith Oswin and Peleg. The fitness of the models were analyzed using coefficient of determinations (R^2), standard error of moisture (*SEM*) and mean relative error percentage (*MRE*). Based on these analyses, Peleg model was found to be the most suitable for describing the sorption data. Monolayer moisture contents and isosteric heats of adsorption estimated usingtheBrunauer-Emmett-Teller (BET) andClausius-Clapeyron equations were respectively found to range between 4.15-5.52% d.b and 1178.93-14042.35 J/mol K.

Keywords: Dried tomato flakes, sorption isotherm, monolayer moisture contents and net isosteric heat.

1.0 Introduction

Tomato is one of the most widely grown, highly consumed and commercially important vegetables in the world. Nigeria had an estimated production of 1.079 million metric tonnes of tomato in 2007 (FAOSTAT, 2007). Owing to its demand there is yearly increase in the cultivation of tomato in Nigeria. Currently, excess supply of tomato usually occurs at the peak period of production while few weeks after, scarcity set-in resulting in high prices. Since not all fresh tomatoes produced can be consumed at the peak period, sun drying into dried flakes and storage usually provides a larger market. In developing countries like Nigeria, sun drying is the traditional method used for the preservation of tomato. In order to develop packaging and storage systems for dried tomato flakes, sorption and thermodynamic information such as sorption energy, monomolecular moisture content and equilibrium moisture content at various water activities are needed.

Al-Muhtaseb et al.(2002) and Menkov et al.(2005) stated that sorption and thermodynamic properties of foods such as equilibrium moisture content, monolayer moisture and isosteric heat of sorption are essential for the design and optimization of many processes such as drying, packaging and storage. Alakali and Satimenhin(2009); Oyelade(2008); Aviara et al. (2006); Marron et al.(2011) and Menkov et al.(2005) achieved sorption studies of various food materials using the static gravimetric method of saturated salts solution or aqueous sulfuric acid solution. Aquasorp isotherm generator was used to construct moisture sorption isotherms of Taro (Nurtama and Lin, 2010). Chayjan and Esna-Asna-Ashari(2010) employed the Artificial Neutral Network Approach for modeling soya beans equilibrium moisture content. Monolayer moisture contents

(*Mo*) indicates the amount of water that is strongly adsorbed to specified sites and it is considered the moisture at which food is most stable(Alakali and Satimehin, 2009, Andrade et al., 2011). According to Hassan(2002), net isosteric heat of sorption is a good measure of the interaction of water vapor with the solid substrate and it is known as the binding energy of sorption. Net isosteric heat of sorption is usually calculated from Clausius-Clapeyron equation, and it is an estimation of the heat required to be removed in excess of latent heat of vaporization of pure water, for extracting absorbed water at particular moisture content (Sahu and Jha, 2008).

Literatures showed that a large number of mathematical models have been developed, modified and applied to describe the sorption isotherms of foods(Ajibola et al., 2004, Aviara et al., 2006, Furmaniak et al., 2009). Some of these models include; Guggenheim-Anderson-de Boer (GAB), Brunauer-Emmett-Teller (BET), Caurie,Oswin, Halsey, Chung-Pfost and Henderson models. Fitness of food isotherm to any of these models depends on many factors. Neuber(1980) gave the important factors that affect food equilibrium moisture content (EMC) values as material components (% oil, fibre, protein, starch), characteristics of material (variety, size), processing of samples (drying method) and equilibration method (relative humidity and temperature control).
The aim of this study is to determine some relevant information that will enhanced storage stability of dried tomato flakes.Specific objectives of the study include: to determine sorption isotherms of dried tomato flakes of Roman VF variety at 10^{o}C, 30^{o}C, and 45^{o}C; to find suitable model describing the isotherms; to estimate the monolayer moisture content and net isosteric heat of sorption of dried tomato flakes.

2.0 MATERIALS AND METHODS

2.1 Tomato Sample Preparation

Freshly harvested full red tomato fruits of Roman VF which is one of the most widely grown varieties in the Northwestern part of Nigeria were collected from a single grower's field at Kudingi in GiwaLocal Government Area of Kaduna State. The fruits were transported in open baskets to Institute for Agricultural Research (I.A.R) crop processing laboratory, Samaru Zaria where the experiment was carried out. The fruits were sorted to remove the damaged ones and undamaged were washed, drained and sliced 20mm thick(Isiaka, 2009)to obtain a uniform drying. The slices were dried using IAR forced convection solar dryer. Dried tomato flakes sample moisture content was determined at 110^{o}C usingoven drying method.

2.2 Weather Simulation

Gravimetric method described by Weast and Astle(1989), Oyelade(2008)and Alakali and Satimehin(2009)was used to control the relative humidity. This involves preparation of various concentrations of sulfuric acid (H_2SO_4) to vary relative humidity in the range of 10 to 80%. Triplicate samples of 10g dried tomato flakes were weighed into wire mesh container placed on plastic stand over and above the solution in airtight glass bottle. The bottles containing the samples and the solution were arranged in an environment maintained at temperatures of 10^{o}C, 30^{o}C and 45^{o}C using ovens and a refrigerator. The samples were weighed every other day until constant weights were attained. Equilibrium moisture contents were determined by oven drying method.

2.3 Models Fitting and Validation

In the study, experimental data were fitted to five isotherm models listed in Table 1. The respective model constants were determined using the solver what-if analysis tool of the

Microsoft Office Excel 2007. The tool was used to minimize the sum of squares of deviations in series of iterative steps by setting the sum of squares cell as the target cell and changing the arbitrarily values set as constants.The validity of the developed relationship between predicted and experimental values of equilibrium moisture content were estimated in terms of coefficient of determination (R^2), mean relative error percentage (*MRE*) and Standard Error of Moisture (*SEM*).

$$SEM = \sqrt{\sum\left(\frac{M_e - M_p}{df}\right)^2} \quad (6)$$

$$MRE(\%) = \frac{100}{N}\sum\left|\frac{M_e - M_p}{M_e}\right| \quad (7)$$

where, *Me* and *Mp* are respectively experimental and predicted values of equilibrium moisture contents, *N* is the number of data points and *df* is the degree of freedom defined as the number of data points minus number of constants in the model.

2.4 Monolayer Moisture Content

The value of the monolayer moisture contents for each temperature levels were estimated using Brunauer-Emmett-Teller (BET) model.

$$\frac{aw}{(1-aw)M} = \frac{1}{M_m} + \frac{(C_b - 1)}{M_m C_b} aw \quad (8)$$

Where *M*=equilibrium moisture content (% d.b); M_m=monolayer moisture content (% d.b); *aw*=water activity (decimal); C_b.is a constant. As described by Ajibola et al. (2004), the BET equation was liken to the straight line equation such that the term $\frac{C_b - 1}{M_m C_b}$ is the gradient and $\frac{1}{M_m C_b}$ is the y-intercept in the graph of $\frac{aw}{(1-aw)M}$ against *aw*.

2.5 Net Isosteric Heat of Sorption

Equation (9) is the integrated form of Clausius-Clapeyron equation employed in determination of net isosteric heat of adsorption.

$$\ln a_w = -\frac{q_{st}}{RT} + C' \quad (9)$$

Where q_{st} is the net isosteric heat of sorption (J/mol), *R* is the gas constant (*R*= 8.314 J/mol K), *T* is the absolute temperature (K) and C' is a constant. Net isosteric heat of sorption of dried tomato flakes was determined by equating gradients of the graphs of ln *aw* against 1/*T* to the term, $-\frac{q_{st}}{R}$ in equation 9.

3.0 RESULTS AND DISCUSSION

Figure 1 showed the sorption isotherm of dried tomato flakes at 10^0C, 30^0C and 45^0C obtained from the mean values of the three replications of equilibrium moisture contents from the experimental data.The curves exhibit sigmoidal shape having an asymptotic trend as the water activity tends toward 1. The curves are categorized as Type II isotherm that is common with soluble foods(Alakali and Satimehin, 2009, Mathlouthi and Roge, 2003). The figure showed that there is arelatively low water sorption for increase in water activity below 0.7 and rapid increase in sorption at water activity above 0.7.

Similar to the isotherms of food materials reported by Lahsasni et al. (2003), Ghodake et al. (2007)and Gazor (2010)equilibrium moisture content was found to have a positive correlation with the water activity. From the results, it is evident that value of equilibrium moisture content decrease with increase in temperature for given water activity of dried tomato flakes. This means that the flakes become less hygroscopic as temperature increase.

The equilibrium moisture content obtained at various water activities and temperatures were used to estimate the coefficients of the sorption models. Estimated coefficients of the Henderson, Halsey, Smith, Oswin and Peleg models, their coefficient of determinations (R^2), standard error of moisture (*SEM*) and mean relative error percentage (*MRE*)are presented in Table 2.

From the tables, it is evident that the modified Peleg model gives better fit to the experimental data with highest R^2 and lowest values of *SEM* and *MRE* percent as compare with other models. Monolayer moisture contents of dried tomato flakes determined using the BET model is presented in Table 3. The results show that monolayer moistures ranged between 4.15-5.52% d.b. The values of the monolayer moisture content obtained fluctuates with increase in temperature and the values are distinct to 16.42%-21.02% at 30ºC for dried tomato pulp (Goula et al., 2008).

The graphs of ln$a_w$against 1/$T$are presented in Figures 2. Using the gradients of the graphs, the values of net isosteric heats of sorption (q_{st}) were calculated and presented in Table 4.

The values of the net isosteric heat of sorption are relatively high at low moisture content less than 10% d.b.This indicates that there is high binding energy needed for removal of water at this point, while the water exists in a relatively free form at moisture content above 10% d.b.A highest net isosteric heat value of 14042.35 J/mol K was recorded at the moisture content of 6% d.b.

4.0 CONCLUSION

The sorption isotherm of dried flakes is categorized as Type II isotherm. The isotherm showed that there is a relatively low water sorption for increase in water activity below 0.7 and there is a rapid increase in sorption at water activity above 0.7. The equilibrium moisture content of dried tomato flakes decrease with increase in temperature for given water activity. Modified Peleg model best fit the experimental data when compared with other models. Monolayer moistures of dried tomato flakes ranged between 4.15-5.52% d.b.The net isosteric heat of sorption is relatively high at moisture content less than 10% d.b. Highest value of net isosteric heat of 14042.35 J/mol K was recorded at the moisture content of 6%.

REFERENCES

Ajibola, O. O., Aviara, N. A. & Abodunrin, V. K. (2004) Sorption Equilibrium And Thermodynamic Properties Of Palm Kernel. *Journal Of Food Technology,* 2**,** 18-27.

Al-Muhtaseb, A. H., Mcminn, W. A. M. & Magee, T. R. A. (2002) Food And Bioprod. Process. 80**,** 118-129.

Alakali, J. S. & Satimehin, A. A. (2009) Moisture Adsorption Characteristics Of Ginger (Zingiber Officinale) Powders. . *Agricultural Engineering International: The CIGR Ejournal. Manuscript* 11.

Andrade, R. D. P., Lemus, R. M. & Pérez, C. E. C. (2011) Models Of Sorption Isotherms For Food:Uses And Limitations. *Vitae Revista De La Facultad De Química Farmacéutica ISSN 0121-4004 / ISSNE 2145-2660. Universidad De Antioquia, Medellín, Colombia,* 18**,** 325-334.

Aviara, N. A., Ajibola, O. O., Aregbesola, O. A. & Adedeji, M. A. (2006) Moisture Sorption Isotherms Of Sorghum Malt At 40 And 50^0C. *Journal Of Stored Products Research* 42 290–301.

Chayjan, R. A. & Esna-Ashari, M. (2010) Modeling Isosteric Heat Of Soya Bean For Desorption Energy Estimation Using Neutral Network Approach. *Chilean Journal Of Agricultural Research,* 70**,** 616-625.

FAOSTAT (2007) *Http:Faostat.Fao.Org/Site/339/Defaut.Aspx Retrieved 5th March, 2012*

Furmaniak, S., Terzyk, A. P., Gołembiewski, R., A., G. P. & Czepirski, L. (2009) Searching The Most Optimal Model Of Water Sorption On Foodstuffs In The Whole Range Of Relative Humidity. *Food Research International,* 42**,** 1203–1214.

Gazor, H. R. (2010) Moisture Isotherms And Heat Of Desorption Of Canola. . *Agricultural Engineering International: The CIGR Ejournal.* ,XII.

Ghodake, H. M., Goswami, T. K. & Chakraverty, A. (2007) Moisture Sorption Isotherms, *Heat* Of Sorption And Vaporization Of Withered Leaves, Black And Green Tea. *Journal Of Food Engineering,* 78**,** 827-835.

Goula, A. M., Karapantsios, T. D., Achilias, D. S. & Adamopoulos, K. G. (2008) Water Sorption Isotherms And Glass Transition Temperature Of Spray Dried Tomato Pulp. *Journal Of Food Engineering,* 85**,** 73–83.

Hassan, B. H. (2002) Moisture Sorption Characteristics Of Dried Date Powder *Journal Of King Saudi University Riyadh. Agric. Sci.* , 14**,** 105-112.

Isiaka, M. (2009) Development Of Low Energy Forced Convection Solar Dryer For Sliced Tomato. *Unpublished Phd. Agric Engineering Thesis. Ahmadu Bello University, Zaria, Nigeria*.

Kane, C. S. E., Kouhila, M., Lamharrar, A., Idlimam, A. & Mimet, A. (2008) Moisture Sorption Isotherms And Thermodynamic Properties Of Tow Mints: Mentha Pulegium And Mentha Rotundifolia. *Revue Des Energies Renouvelables,* 11**,** 181 – 195.

Lahsasni, S., Kouhila, M., Mahrouz, M. & Fliyou, M. (2003) Moisture Adsorption Desorption Isotherms Of Prickly Pear Cladode (Opuntia Ficus Indica) At Different Temperatures. *Energy Conversion And Management,* 44**,** 923-936.

Marrón, R. M., Chanes W. J., Quiroz C. A.V., Bretón C. J.G., Bretón C. R.M. & Franseschi A.F. (2011) Estimation Of Moisture Sorption Isotherms Of Mango Pulp Freeze- Dried. *International Journal Of Biology And Biomedical Engineering,* 5.

Mathlouthi, M. & Roge, B. (2003) Water Vapour Sorption Isotherms And The Caking Of Food Powders. *Food Chemistry,* 82**,** 61-71.

Menkov, N. D., Durakova, A. G. & Krasteva, A. (2005) Moisture Sorption Isotherms Of Common Bean Flour At Several Temperatures. *Electronic Journal Of Environmental, Agricultural And Food Chemistry.,* 4**,** 892-898.

Neuber, E. E. (1980) Critical Considerations Of Moisture Sorption Isotherms For Cereals. *Transaction Of The American Society Of Agricultural Engineers ASAE***,** 3015.
Nurtama, B. & Lin, J. (2010) Moisture Sorption Isotherm Characteristics Of Taro Flour. *World Journal Of Dairy And Food Sciences,* 5**,** 01-06.
Oyelade, O. J. (2008) Equilibrium Moisture Content Models For Lafu. *International Journal Of Food Engineering.,* 4.
Sahu, J. K. & Jha, A. (2008) Storage Stability Of Sandesh - An Indian Milk Sweet. *Agricultural Engineering International: The CIGR Ejournal, Vol. X.*
Weast, R. C. & Astle, M. J. (1989) *Handbook Of Chemistry And Physic,* USA, CRC Press Inc. Basa Raton Florida, .

Table 1: Models equations and references

Model	Model equation	No. of equation	References
Henderson	$M = \frac{\ln(1-aw)}{At}\left(\frac{t}{B}\right)$	1	Oyelade, (2008)
Halsey	$M = \left(\frac{-A}{\ln aw}\right)^{\frac{1}{B}}$	2	Marron et al. (2011)
Smith	$M = A + B\ln(-\ln aw)$	3	Marron et al. (2011)
Oswin	$M = A\left(\frac{aw}{1-aw}\right)^{B}$	4	Forminiak et al. (2009)
Peleg	$M = A(aw)^{C} + B(aw)^{D}$	5	Kane et al.(2008)

Where M=equilibrium moisture content (% d.b); M_o=monolayer moisture content (% d.b); aw=water activity (decimal); t=temperature (^{o}C); A, B,C and D are constants.

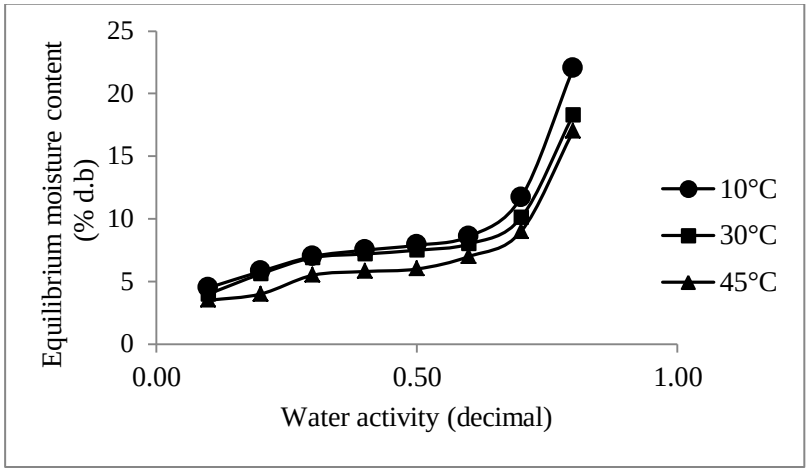


Figure 1: Sorption isotherm of dried tomato flake at various temperatures

Table 2:Coefficients of sorption models

Model	Model constants				R^2	*SEM*	*MRE (%)*
	A	*B*	*C*	*D*			
Henderson	199999	-0.001	-	-	0.485	5.634	59.782
Halsey	1.313	0.302	-	-	0.894	2.232	28.234
Smith	6.917	-5.307	-	-	0.731	2.456	22.740
Oswin	8.039	0.529	-	-	0.821	2.041	20.957
Peleg	9.246	164.336	0.350	12.303	0.945	1.157	10.671

Table 3: Monolayer moisture contents of dried tomato flake

Temperature (^{o}C)	Monolayer moisture Content (%d.b)
10	4.15
30	5.52
45	5.32

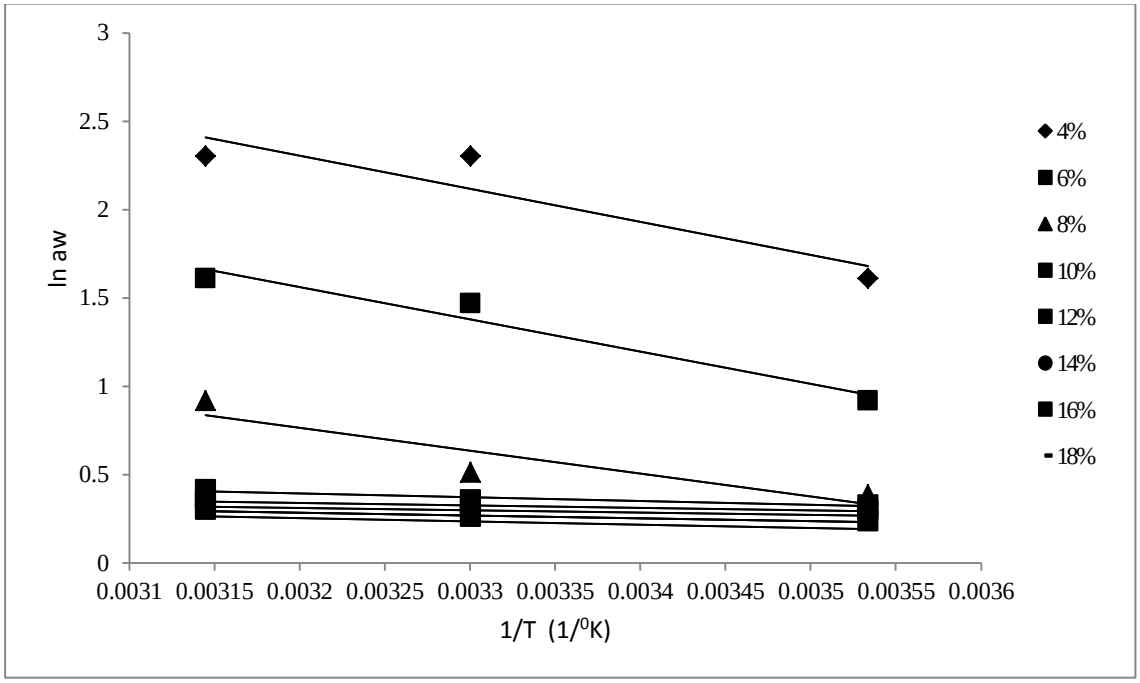


Figure 2: Graphs of ln aw against 1/T

Table 4: Net isosteric heat of sorption of dried tomato flakes

M (%d.b)	Net isosteric heat (J/mol K)
4	13651.59
6	14042.35
8	11581.40
10	1878.13
12	1205.53
14	1178.93
16	1398.41
18	1640.35

EFFECT OF MOISTURE CONTENT ON THE STATIC COEFFICIENT OF FRICTION OF SELECTED CEREALS AND LEGUMES IN NIGERIA

N.A. Aviara., A. A. Lawal., S.A. Rimamnuskep and S.A. Adimora

Department of Agricultural and Environmental Resources Engineering, Faculty of Engineering, University of Maiduguri, Maiduguri, Borno State, Nigeria.abulawal2010@gmail.com

ABSTRACT

The static coefficient of friction of soya bean, cowpea, locust bean, maize and milleton four structural surfaces namely glass, galvanized metal sheet, plywood and hesian bag, was determined at different moisture contents using an apparatus operating on the principle of tilting surface. In the moisture ranges of 4.3 to 21.6, 7.4 to 22.4, 4.3 to 14.7, 7.6 to 21.1% (d.b.) the static coefficient of friction of soya bean, cowpea, locust bean, maize and millet increased from 0.361 to 0.481, 0.377 to 0.585, 0.331 to 0.609, 0.367 to 0.502 and 0.331 to 0.613, respectively, and varied with structural surface. Of all the above crops, millet had the highest static coefficient of friction which occurred on plywood, while locust bean and millet had the lowest value on glass surface. The relationship existing between the static coefficient of friction and grain moisture content on specified structural surface was expressed by regression models.

Keywords: soya bean, cowpea, locust bean, maize, millet, static coefficient of friction, moisture content, structural surface, Nigeria

1. 0. Introduction

The Nigerian agricultural sector is presently experiencing rapid development, and as a result, farmers are learning to produce crops in commercial quantities. The crops need to be handled, processed and stored as the case may be.

The traditional method of handling, processing and storing the grain include beating of the panicle against a hard element, separation of kernel from cob by thumbs; winnowing with the aid of the wind; metering and packaging in glass or plastic container and conveying to storage structures or markets for sale.Because the aboveoperationsare carried out manually, they result in poor man-hour utilization and losses of grains (FAO,1994). Improved methods of handling, processing and storing the grains using suitable machines and equipment require the knowledge of such engineering properties of grain as static coefficient of friction.

Static coefficient of friction is used to determine the angle at which chutes must be positioned in order to achieve material free flow through the chute (Razavi and Farahmanfar, 2008; Zareiforoush et al., 2009). GhasemiVarnamkhasti et al., (2008) reported that static coefficient of friction is useful in the sizing of electric motors required for grain handling and transportation. Static coefficient of friction has a fundamental application in the determination of pressure exerted by stored products on the walls and floors of storage structures (Mohsenin, 1986;Gumble and Maina, 1990), so it is a useful parameter in the design of storage facilities (Tavakoli et al., 2009b;Seifi and Alimardani, 2010).To estimate the power needed by a power source to start a loaded auger, the coefficient of friction related to the force of static friction that must be

overcome is necessary. The coefficient of friction of the material to be chopped is needed in the design of impeller units (Mohsenin, 1986).

Investigators have determined the static coefficient of frictionof grains and seed using several methods and these include moving a given surface against the material (Lawton, 1980), tilting an inclined plane (Mohsenin , 1986; Aviara et al., 1999; Tabatabaeefar, 2003; Zaalouk and Zabady, 2009) and the shear box equipment (Osunade and Lasisi, 1994; Molenda et al., 2000).Brubaker and Pos, (1965),Dutta et al., (1988)and Rusinek and Molenda, (2007) investigated the static coefficient of friction of different grains and noted it to be moisture dependent and to vary with structural surface. Similar findings were reported by Aviara et al., (1999), Zareiforoush et al., (2009), Tavakoli et al., (2009a), Nwakonobi and Onwualu, (2009),Seifi and Alimardani(2010), and Tarighi et al., (2011). The objective of this study was to determine the static coefficient of friction of soya bean, cowpea, locust bean, maize and millet on the glass, galvanized metal, plywood and hessian bag surfaces, and investigate its variation with grain moisture content.

2.MATERIALS AND METHODS

2.1 Sample Collection and Conditioning

For this work, bulk quantities of soya bean and locust bean seeds were procured from Fikyu village, in Ussa Local Government Area of Taraba State, Nigeria. Cowpea, maize and millet were obtained from the Department of Crop Production, University of Maiduguri, Maiduguri,Borno State, Nigeria. The grains were cleaned and sampled for experiments. The initial moisture contents of the grains were determined using the ASABE (2008) standard. This involved oven drying of grain samples at 105^{o}C to constant weight. Grain samples of desired moisture content levels were prepared by conditioning the samples using the method of Ezeike, (1986). This involved soaking of the different bulk samples in clean water for a period of 1 to 3 hours, followed by spreading out in a thin layer to dry in natural air for about 8 hours. Then, the bulk samples were sealed individually in separate polyethylene bags and stored in that condition for a further 24 hours. This allowed for a stable and uniform moisture content of the samples to be achieved.

2.2 Determination of Static Coefficient of Friction

The static coefficient of friction was determined with respect to four structural surfaces namely; plywood, galvanized iron, glass and hessian bag surfaces using the inclined plane method (Dutta et al., 1988,Mohsenin, 1986). This involved placing an open-ended box on an adjustable tilting surface equipment (Figure 1) with the surface formed using a structural material. The box was filled with grain sample and the structural surface with the box and its content on top was gradually raised using a screw device until the box just started to slide down. The angle of tilt was recorded and the static coefficient of friction was calculated using the following equation:

$$\mu_s = \tan\alpha \qquad (1)$$

whereμ_s is the static coefficient of friction and α is the angle of tilt in degrees.

The experiment was conducted on all the grains – soya bean, cowpea, locust bean, maize and millet - at different moisture levels and replicated three times. Data obtained were subjected to analysis of variance (ANOVA) and LSD's test using statistix version 9. Static coefficient of friction was then regressed against moisture content and the function relating it with moisture content for each crop on a structural surface was established.

3.RESULTS AND DISCUSSION

3.1 Grain Moisture Content

The initial moisture content of soya bean, cowpea, locust bean, maize and millet were found to be 4.3, 7.4, 4.3, 7.6 and 7.5% (d.b.) respectively. The three other moisture levels obtained after conditioning the grains were 14.2, 18.2 and 21.6% (d.b.) (soya bean); 15.7, 18.3 and 22.4% (d.b.) (cowpea); 7.6, 12.3 and 14.7% (d.b.) (locust bean); 12.0, 19.1 and 21.1% (d.b.) (maize); and 9.1, 12.8 and 14.6% (d.b.) (millet). Investigations were carried out at the above moisture content levels to determine the effect of moisture content on the static coefficient of friction of the grains.

3.2 Grains Static Coefficient of Friction

The static coefficientsof friction of the grains on four structural surfaces measured at different moisture content levels are presented in Table 1. The variations of static coefficient of friction of the grains with moisture content and structural surfacesare depicted in Figures 2-6.

The F-ratios ofcoefficient of friction for soya bean, cowpea, locust bean, maize and millet obtained from ANOVA arepresented in Table 2. From Table 2, it can be seen that grain moisture content, structural surface and their interaction significantly affected the static coefficient of friction of the grains at 1% level of significance.

3.2.1Soya bean

The static coefficient of friction of soya bean increasedexponentially with increase moisture content within the moisture range of 4.3 to 21.6% (d.b.) on galvanized iron, plywood and hessian bag, while on glass it increased within moisture range 4.3 to 18.2% (d.b.) to a maximum value of 0.419, after which it decreased with further increase in moisture content (Figure 2) and exhibited logarithmic relationship with moisture content. The highest value of 0.481 was obtained on the surface of hessian bagand the lowest value of 0.361 was on glass surface.

The relationship existing between the static coefficient of friction of soya bean and moisture content on different structural surfaces can be expressed using the following equations:

$$\mu_{hbs} = 0.47 + 2.93\times10^{-6} (\text{Exp } 0.383M), \quad R^2=0.997 \qquad (2)$$

$$\mu_{pws}=0.422 (\text{Exp } 0.004M), \quad R^2=0.968 \qquad (3)$$

$$\mu_{gss}=0.412(\text{Exp } 0.004M), \quad R^2=0.865 \qquad (4)$$

$$\mu_{gls}=0.321 + 0.031 (\ln M), \quad R^2=0.912 \qquad (5)$$

where R^2 is coefficient of determination, μ_{hbs}, μ_{pws}, μ_{gss} and μ_{gls} are the static coefficients of friction of soya bean on hessian bag, plywood, galvanized iron sheet and glass respectively, and M is moisture content % (d.b).

3.2.2 Cowpea

Figure 3 shows the variation of static coefficient of friction of cowpea with moisture content on different structural surfaces. The static coefficient of friction increased logarithmically with increase in moisture content on all surfaces. The highest value of 0.585 was obtained at 22.4% (d.b.) moisture content on the surface of hessian bag and the lowest value of 0.377 was at 7.4% (d.b.) moisture content on glass surface.

The static coefficient of friction of cowpea on different structural surfaces as related tomoisture content can be expressed using the following equations:

$$\mu_{hbc}=0.22 + 0.116 (\ln M), \quad R^2=0.988 \qquad (6)$$

$$\mu_{pwc}=0.108 + 0.141 (\ln M), \quad R^2=0.985 \qquad (7)$$

μ_{gsc}=0.196 + 0.093 (ln M), R^2=0.988 (8)

μ_{gsc}=0.181 + 0.101 (ln M), R^2=0.992 (9)

whereμ_{hbc}, μ_{pwc}, μ_{gsc} and μ_{glc} are the static coefficients of friction of cowpea on hessian bag, plywood, galvanized iron sheet and glass respectively.

3.2.3Locust bean

The static coefficient of friction of locust bean increased from 0.331 to 0.488 on glass, 0.367 to 0.577 on galvanized iron, 0.367 to 0.589 on plywood, and 0.470 to 0.609 on hessian bag within the moisture range of 4.3 to 14.7% (d.b.). Thehighest value obtained was at 14.7% (d.b.) on hessian bag and lowest value was at 4.3% (d.b.) on glass (Figure 4).

The relationshipexisting between the static coefficient of friction on the structural surfaces and moisture content was found to be logarithmic and can be expressed using the following equations:

μ_{hbl}=0.335 + 0.104 (ln M), R^2=0.857 (10)

μ_{pwl}=0.141 + 0.165 (ln M), R^2=0.964 (11)

μ_{gsl}=0.159 + 0.155 (ln M), R^2=0.976 (12)

μ_{gll}=0.179 + 0.121 (ln M), R^2=0.976 (13)

whereμ_{hbl}, μ_{pwl}, μ_{gsl} and μ_{gll} are the static coefficients of friction of locust bean on hessian bag, plywood, galvanized iron sheet and glass respectively.

3.2.4Maize

Figure 5 shows the variation of static coefficient of friction of maize with moisture contenton different structural surfaces. The coefficient of static friction increased exponentially with moisture content in the moisture range of 7.6 to 21.1% (d.b.), with the highest value of 0.502 obtained at the moisture content of 21.1% (d.b.) on hessian bag and lowest value of 0.361 at 7.6% (d.b.) moisture content on plywood.

The following equations could be used to express the relationship existing between the static coefficient of friction of maize and moisture content on different structural surfaces:

μ_{hbma}=0.503 (Exp -1.061/M), R^2=0.725 (14)

μ_{pwma}=0.347 (Exp 0.004M), R^2=0.945 (15)

μ_{gsma}=0.34 (Exp 0.011M), R^2=0.999 (16)

μ_{glma}=0.349 (Exp0.006M), R^2=0.990 (17)

whereμ_{hbma}, μ_{pwma}, μ_{gsma} and μ_{glma} are the static coefficients of friction of maize on hessian bag, plywood, galvanized iron sheet and glass respectively.

3.2.5Millet

The static coefficient of friction of millet increased logarithmically with moisture content in the moisture range of 7.5 to 14.6% (d.b.) and varied with structural surface (Fig.6). The highest value of 0.613 was obtained at 14.6% (d.b.) moisture content on the surface of plywood and the lowest value of 0.331 at 7.5% (d.b.) moisture contentwas on glass surface.

The relationship existing between the static coefficient of friction of millet and moisture content can be expressed for different structural surfaces using the following equations:

μ_{hbml}=0.061 + 0.197 (ln M), R^2=0.792 (18)

μ_{pwml}=-0.081 + 0.255 (ln M), R^2=0.96 (19)

$$\mu_{gsml}=0.126 + 0.126 (\ln M), \quad R^2=0.993 \qquad (20)$$

$$\mu_{glml}=0.072 + 0.133 (\ln M), \quad R^2=0.996 \qquad (21)$$

whereμ_{hbml}, μ_{pwml}, μ_{gsml} and μ_{glml} are the static coefficients of friction of maize on hessian bag, plywood, galvanized iron sheet and glass respectively.

Table 3 shows the range of variation of static coefficient of friction of the grains with moisture content levels on the different structural surfaces. From Table 3, it canbe seen that locust bean had the widest range followed by cowpea, millet and maize, and soya bean had the narrowest range on all surfaces. This shows that variation in moisture content of locust bean rapidly change the static coefficient of friction, while variation in moisture content of soya bean slowly change the static coefficient of friction. The static coefficients of friction of the grains have the highest values on hessian bag, while the lowest values were on glass surface. Locust bean had the highest static coefficients of friction within the moisture range on hessian bag followed by cowpea, millet, soya bean and maize. Maize had the lowest static coefficient of friction value on glass surface followed by millet, soya bean, locust bean and cowpea.

4. CONCLUSIONS

1. The static coefficient of friction of soya bean, cowpea, locust bean, maize and millet increased with moisture content and varied on structural surface.
2. Millet recorded the maximumstatic coefficient of friction on plywood, while locust bean and millet had the minimum value on glass surface.
3. Locust bean shows rapid change of static coefficient of friction due to moisture content variation followed by cowpea, millet, maize and soya bean
4. The hessian bag recorded the highest value of static coefficient of friction, while glass produces the least values.

REFERENCES

ASABE (2008).Moisture measurement- unground grain and seeds. ASAE S352.2 APR 1988.ASABE Standards, p. 668. American Society of Agricultural and Biological Engineers.2950 Niles Road, st. Joseph, Michigan, www.asabe.org.

Aviara N.A., Gwandzang M.I, and Haque M.A., (1999).Physical properties of guna seeds.Journal of Agricultural Engineering Research, 73: 105-111.

Brubaker, J.E. and Pos, (1965). Determination og static coefficients of grains on structuralSurfaces. Transactions of ASAE 8:53-55

Dutta S.K., Nema V.K., and Bhardwaj R.K., (1988).Physical properties of gram. Journal ofAgricultural Engineering Research, 39: 259-268.

Ezeike G.O.I., 1986. Quasi-static hardness and elastic properties of some tropical seed grains and tomato fruit. International Agrophysics, 2:15-29.

FAO, (1994).Grain storage techniques - Evolution and trends in developing countries.FAO agricultural Services Bulletin No. 109. FAO, Rome.

GhasemiVarnamkhasti, M., Mobli, H., Jafari, A., Keyhani, A. R., HeidariSoltanabadi, M.,Rafiee, S. and Kheiralipour, K. (2008).Some physical properties of rough rice (oryzasativa) grain. Journal of Cereal Science, 47: 496-501.

Gumble, L. O. and Maina, C. (1990). Friction coefficient of cereal seeds on various surfaces.Agricultural mechanization in Asia, Africa and Latin America, 21(4): 61-64.

Lawton P.J., (1980).Coefficient of friction between cereal grain and various silo wallmaterials. Journal of Agricultural Engineering Research, 25: 75-86.

Mohsenin N.N., (1986). Physical Properties of Plant and Animal Materials. 2nd edition(revised). Gordon and Breach Science Publishers, New York.

Molenda M., Thompson, S. A. and Ross, I. J. (2000). Friction of wheat on corrugated and Smooth galvanized steel surfaces. Journal of Agricultural Engineering Research, 77: 209-219

Nwakonobi, T.U. and Onwualu, A. P. (2009).Effect of moisture content and structural surfaces on coefficient of friction of two Nigerian food grains: Sorghum (sorghum bicolor)and millet (pennisetumglaucum). Agricultural Engineering International: the CIGR ejournalManuscript 1152, volume XI, www.cigrjournal.org

Osunade, J. A. and Lasisi, F (1994). Coefficient of friction of maize and sorghum grains onlaterized concrete wall. NSE Technical Transaction, 29: 50-57.

Razavi, S. M. A. and Farahmandfar, R. (2008).Effect of hulling and milling on the physical properties of rice grains. International Agrophysics, 22: 353-359.

Rusinek, R. and Molenda, M. (2007).Static and kinetic friction of rape seed. Research inAgricultural Engineering, 53(1): 14-19.

Seifi, M. R. and Alimardani, R. (2010).The moisture content effect on some physical and Mechanical properties of corn (sc. 704). Journal of Agricultural Science, 2(4): 125-134.

Tabatabaeefar, A. (2003).Moisture dependent physical properties of wheat. InternationalAgrophysics, 17: 207-211.

Tarighi J., Mahmoudi A., and Alavi N. (2011).Some mechanical and physical properties ofCorn seeds. African Journal of Agricultural Research, 6 (16): 3691-3699

Tavakoli, M., Tavakoli, H., Rajabipour, A., Ahmadi, H. and Gharib-Zahedi, S. M. T.(2009a). Moisture-dependent physical properties of barley grains. International Journal ofAgricultural and Biological Engineering, 2(4): 84-91.

Tavakoli, H., Rajabipour, A., and Mohtasebi, S.S. (2009b).Moisture-dependent of some Engineering properties of soybean grains. Agricultural Engineering Internatioanal: theCIGR ejournal. Manuscript 1110, volume XI, www.cigrjournal.org.

Zaalouk, A. k. and Zabady, F. I. (2009).Effect of moisture content on angle of repose and friction coefficient of wheat grain.Misra Journal of Agricultural Engineering, 26(1):418-427.

Zareiforoush H., Komarizadeh M.H. and Alizadeh M.R. (2009).Effect of Moisture Contenton Some Physical Properties of Paddy Grains.Journal of Applied Sciences, Engineeringand Technology,1(3): 132-139.

Table 1. Static coefficient of friction of some agricultural grains at different moisture contents and on different structural surfaces

		Static coefficient of friction (μ_s)			
		Structural surfaces			
Grain type	Moisture cont.% (d.b.)	Glass	Galvanized iron	Plywood	Hessian bag
Soya bean	4.3	0.361(0.015)	0.424 (0.010)	0.431(0.006)	0.470(0.022)
	14.2	0.418(0.006)	0.424 (0.006)	0.442(0.006)	0.470(0.027)
	18.2	0.419(0.018)	0.435 (0.024)	0.452(0.018)	0.473(0.016)
	21.6	0.397(0.012)	0.459 (0.006)	0.463(0.006)	0.480(0.025)
Cowpea	7.4	0.377(0.006)	0.381 (0.006)	0.384(0.020)	0.452(0.012)
	15.7	0.473(0.016)	0.456 (0.018)	0.510(0.029)	0.539(0.024)
	18.3	0.477(0.043)	0.473 (0.012)	0.521(0.019)	0.547(0.024)
	22.4	0.481(0.006)	0.480 (0.012)	0.532(0.022)	0.585 (0.014)
Locust bean	4.3	0.331(0.015)	0.367 (0.007)	0.367(0.021)	0.470(0.016)
	7.6	0.473(0.012)	0.513 (0.006)	0.510(0.019)	0.581(0.007)
	12.3	0.477(0.011)	0.524 (0.017)	0.532(0.006)	0.585(0.014)
	14.7	0.488(0.019)	0.577 (0.012)	0.589(0.030)	0.609(0.037)
Maize	7.6	0.367(0.021)	0.367 (0.015)	0.361(0.006)	0.438(0.016)
	12.0	0.377(0.006)	0.387 (0.006)	0.404(0.010)	0.463(0.006)
	19.1	0.384(0.017)	0.414 (0.006)	0.422(0.052)	0.449(0.022)
	21.1	0.407(0.012)	0.425 (0.018)	0.414(0.027)	0.502(0.013)
Millet	7.5	0.331(0.015)	0.370 (0.011)	0.418(0.006)	0.428(0.016)
	9.1	0.377(0.006)	0.418 (0.012)	0.510(0.029)	0.539(0.024)
	12.8	0.404(0.018)	0.438 (0.006)	0.547(0.007)	0.562(0.013)
	14.6	0.428(0.006)	0.466 (0.018)	0.613(0.012)	0.578(0.041)

Numbers in parentheses are standard deviations; cont. is content; d.b. is dry basis.

Table 2. F-ratios for the ANOVA of static coefficient of friction of selected grains with moisture content and structural surface

source of variation	F- ratio				
	soya bean	cowpea	locust bean	maize	millet
moisture content (MC.)	52.36*	214.46*	501.92*	28.70*	574.92*
structural surface (SS)	193.28*	242.19*	527.63*	122.11*	612.15*
Interaction MC*SS	9.88*	6.71*	17.95*	4.16*	15.22*

*significant at 1% level.

Table 3. Range of variation of static coefficient of friction due to change in grain moisture content

	Range	of static	coefficient	of friction	
Structural	Soya bean	Cowpea	Locust bean	Maize	Millet
Surface	4.3-21.6% (d.b.)	7.4-22.2% (d.b.)	4.3-12.7% (d.b.)	7.6-21.1% (d.b.)	7.5-14.6% (d.b.)
Glass	0.3658	0.10335	0.15642	0.04008	0.09651
G/iron	0.03476	0.09965	0.21012	0.05723	0.0958
Plywood	0.03142	0.1479	0.22196	0.05369	0.019521
Hesian bag	0.01072	0.1329	0.13929	0.06392	0.14986

G/iron, galvanized iron; d.b., dry basis



Figure 1. Static coefficient of friction apparatus with adjustable tilting surface

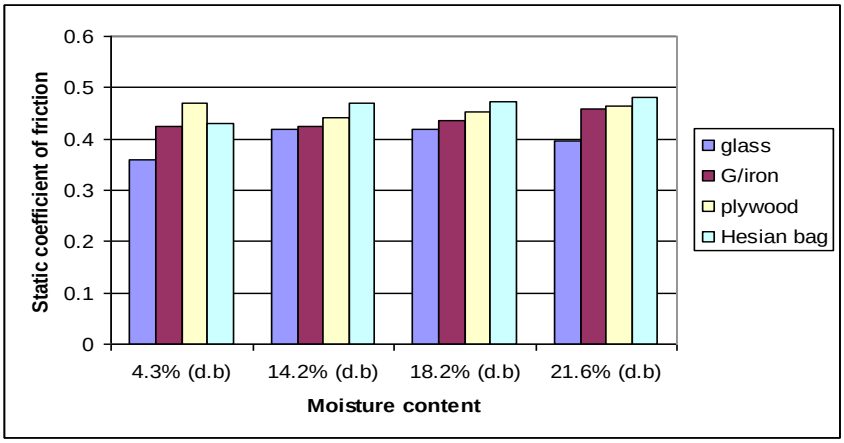


Figure 2. Variation of static coefficient of friction of soya bean with moisture content and structural surface.

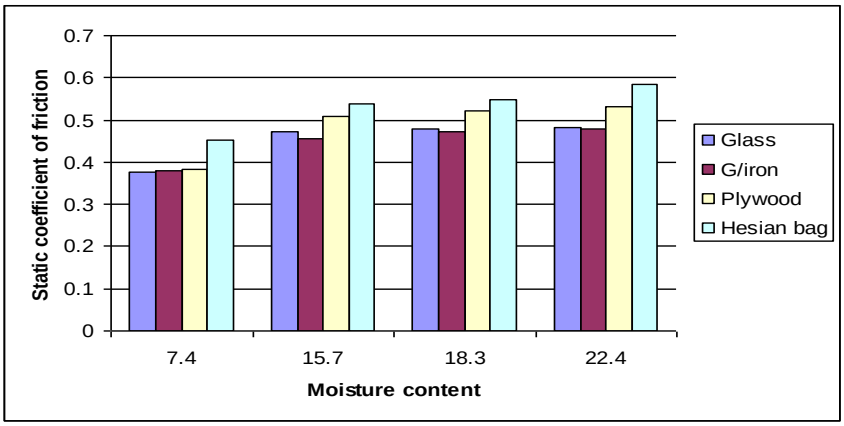


Figure 3.Variation of static coefficient of friction of cowpea with moisture content and structural surface.

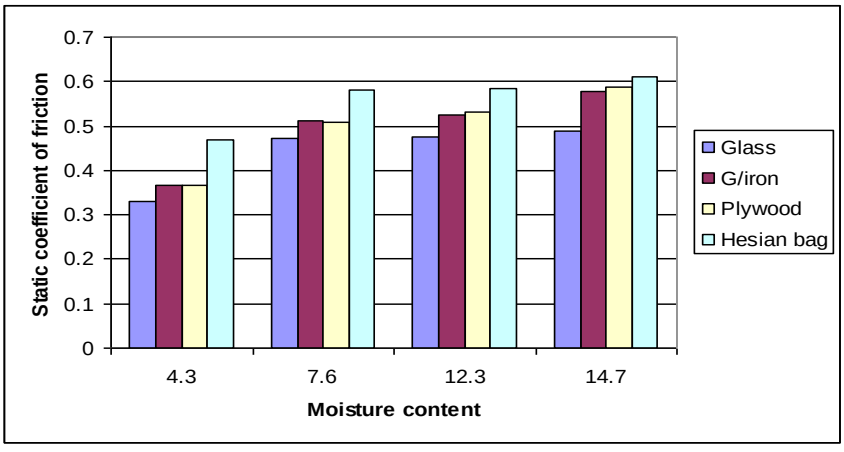


Figure 4.Variation of static coefficient of friction of locust bean with moisture content and structural surface.

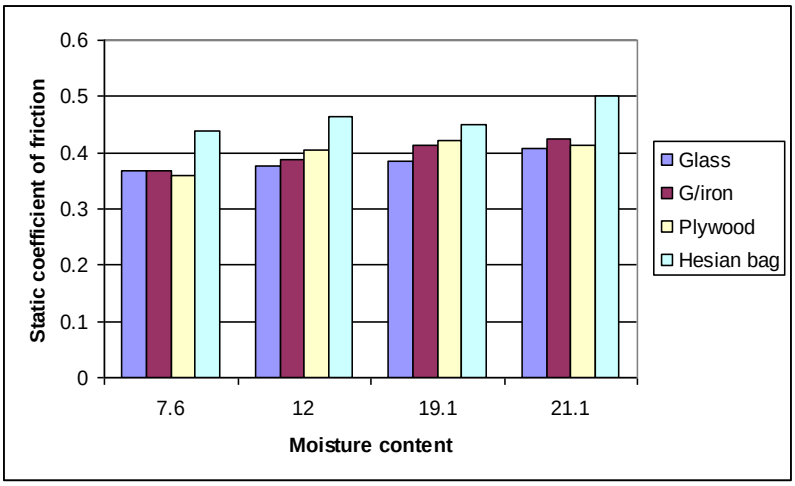


Figure 5.Variation of static coefficient of friction of maize with moisture content and structural surface.

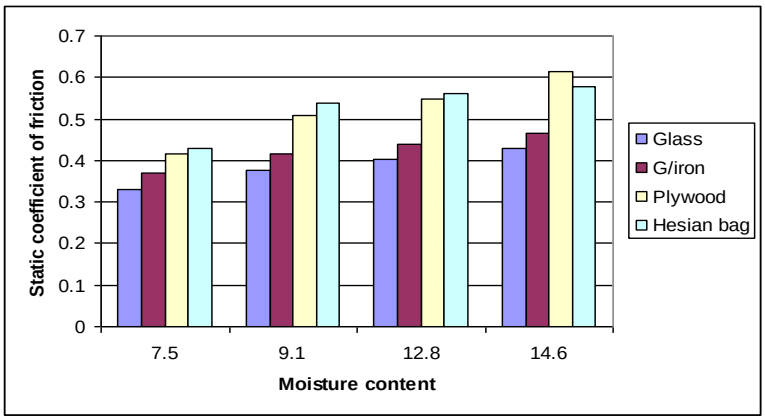


Figure 6.Variation of static coefficient of friction of millet with moisture content and structural surface.

EFFECT OF MOISTURE CONTENT, PARTICLE SIZE AND TEMPERATURE ON THE SPECIFIC HEAT OF PRESERVED GROUND SHEANUT KERNEL (*BUTYROSPERNUMPARADOXUM*)

Nwannewuihe, H.U, Onwukwe M. C., Edeh J.C and Nwagugu N. I.

Engineering, research, development and production department (erdp).projects development institute, (proda) emene, enugu.morale774@gmail.com. +234 8054450443

ABSTRACT

Most agricultural materials undergo various forms of preservation in order to enhance shelf life. Sheanut is usually preserved by heating the kernels over fire in a pot for a time period. This affects its properties especially during heat processing. It is expected that this work will provide information that would help optimize such processing. Preserved sheanut kernel samples sourced locally were prepared by manually cleaning, sorting, grinding and sieving to obtain desired particle sizes. The specific heat of the samples were evaluated as a function of particle size (2.36mm {P_1}, 1.18mm {P_2} and 1.00mm {P_3}), moisture content (initial moisture content, 10, 20, 30 and 40% db) and temperature (50, 60, 70, 80, and 90^{o}C). The specific heat of each particle size increased with increase in moisture content and varied with temperature with values in the range of 2674 to 4114.67, 1952.08 to 4401.82, and 2429.05 to 4343.87 Jkg^{-1o}C^{-1} for P_1, P_2 and P_3 respectively. It was observed that the effect of moisture content was greater than both particle size and temperature. The relationships that existed between specific heat and the observed variables were best described by trinomial modelequations with attendant (R^2)values. Application of these equations will aid in predicting the specific heat of ground preserved sheanut samples as a function of the observed variables**.**

Keywords: Specific Heat, particle size, moisture content, temperature, sheanut

1.0 Introduction

Vitellaraparadoxa, the Shea butter tree, grows throughout Sahelian Africa, from Senegal to Ethiopia. The trees are multi-purpose and are highly valued not only for the economic and dietary value of the cooking oil, but also for the fruit pulp, bark, roots and leaves, which are used in traditional medicines, for the wood and charcoal as cooking fuel, and also for building. Shea nut (*vitellariaparadoxa*) is of a botanical family *sapoteceae* and has a botanical name *Butryospermumparkli* with other names such asKarite (French), Nku(Ghana) and Ese (Yoruba). European explorers first recorded Shea in the early 18th century and by the 1920s, a flourishing trade was developing between West Africa and Europe. The oldest known botanical specimen of *Vitellaria* was apparently collected by Mungo Park, and is currently held in the Natural History Museum in London (Hall *et al*, 1996). The shea-butter grows everywhere in West and West-Central Africa, where the oil palm does not. In Northern Nigeria especially, it flourishes over large areas. It has fleshy fruits which grow in bunches, are ovoid in shape like an avocado with deep green or brown colour. The sweet pulp is edible and inside the fruit is a nut surrounded by a thin shell containing a hard kernel and a whitish almond-like nut that contains fat equal to about 50% of its weight, called shea butter. Despite its various uses, there is no known plantation of sheanut and little information is available on the existence of commercial plants for the purpose of processing the oil (Oluwole, 2004).

When shea fruits are harvested, they undergo traditional methods of extraction mostly performed by women and children (Adgidzi*et al.* 2003). These traditional methods comprise activities such as collection and cleaning of nuts by removal of unwanted materials which include stones, grass and dirt. They are usually eaten to de-pulp them and the resulting nuts are boiled and then cracked to give the kernels. These kernels are sun dried to a safe storage moisture content of about 10-15% before oil extraction (Wiemer and Korthals, 1989).

Researchers have investigated specific heat as a function of process conditions and physico-chemical properties of the biomaterials and their findings are reported in literature. The specific heat of rice bran in the moisture and temperature ranges of 4.3-18% and 38-63°C respectively was reported by Sreenarayanan and Chattopadhyay, (1986), while the specific heat of cumin seed was observed to increase with increase in temperature from -70 to 50°C and moisture content from 1.8-20.5% (d.b) as reported by Singh and Goswami (2000). The specific heat of minor millet grains and flours increased from 1.33 to 2.40 kJ/kg°C with moisture content in the range of 10- 30% (w.b) as reported by Subramanian and Viswana than (2003). Opoku*et al*., (2006) using the method of indirect mixtures studied the specific heat of timothy hay, while the specific heat of four varieties of Iranian pistachio nuts as affected by moisture content and temperature was studied by Razavi and Taghizadeh (2007.)

Aviara and Haque (2001) while investigating the moisture dependent thermal properties of sheanut kernels reported thatits specific heat, lies between 1792 and 3172 J/kg K at four moisture levels in the range of 3.32-20.70%(db) and five temperature ranges (303-363K, 303.4-333K, 303-343K, 305-353K and 306.5-363K). Aremu and Nwannewuihe (2011) reported that the specific heat of ground fresh sheanut kernels were 2679.75 to 4230.17, 1952.08 to 4401.82 and 1716.84 to 4353.03 $Jkg^{-1}{}^{o}C^{-1}$for selected particle sizes of 1.00mm, 1.18mm and 2.36mm. This study was aimed at determining the specific heat of ground preserved sheanut kernels for the same particle size range. With the challenge of deforestation and due to the seasonal nature of sheanut, it is usually roasted over fire to preserve it. Hence it is expected that the results of this research would provide information on the effects of this method of preservation on the specific heat of the crop. It is also expected to help in the design of process equipment and process optimization especially during the extraction of its oil (shea butter) since sheanut undergoes a lot of heat processing in its ground form.

2.0 MATERIALS AND METHODS

2.1 Sample Preparation

The shea kernels were obtained locally from Doko village in Lavun L.G.A Niger state, Nigeria. The samples, already roasted for preservation using local methods were cleaned to remove dust, particles and other unwanted debris. Sorting was done to separate broken kernels from whole kernels which were selected for the experiment. The selected kernels were ground and sieved to get the desired particle sizes 2.36mm (P_1), 1.18mm (P_2) and 1.00mm (P_3) respectively.



P_1 P_2 P_3

Figure1: Particle sizes of sample.

(Source; Nwannewuihe, 2010)

2.2 Moisture Content Determination

The hot air oven method (AOAC, 2002) was used to determine the moisture content of the samples.30g of the sample was placed in a container of known weight and dried in an oven at 105°C to constant weight. The moisture content in % dry basis was found by applyingequation (1) below as reported by Bup et al 2008.

$$M_c(\%db) = \left(\frac{M_i - M_f}{M_f}\right) x100\% \quad (1)$$

Where M_c is the Moisture content, M_i is the initial mass of sample and container (g),M_f is the final mass of sample and container (g) at constant weight. This was replicated six times and the average value taken as the initial moisture content of the samples. The initial moisture content of the samples was 3.26% (db). The ground samples were conditioned to 10, 20, 30 and 40% (db) by adding 7.5, 20.9, 38.2 and 54.5g of water Q as calculated from the following relation to 100g of sample:

$$Q = A(b - a)/ (100 - b) \quad (2)$$

Where:

A = the initial mass of the sample in g

a =the initial moisture content of sample (% dry basis)

b = is the desired or final moisture content of the sample (Balasubramanian, 2001).

2.3 Determination of Specific Heat of Ground Sheanut Kernel

The most common technique for measuring the specific heat of biomaterials from literature is the method of mixtures as reported by Mohsenin(1980) and Tabil(1999). The specific heat of the samples was determined with the aid of a calibrated copper calorimeter placed inside a flask, using the method of mixtures. The calorimeter was calibrated by pouring a measured quantity of cold water, $\boldsymbol{M_{cw}}$, into it. The

temperature of the cold water was allowed to stabilize at $\boldsymbol{Tc}$, and a measured quantity of hot water $\boldsymbol{M_{hw}}$ at a known temperature $\boldsymbol{T_h}$, was added. The equilibrium temperature $\boldsymbol{T_e}$ of the mixture of hot and cold water was recorded. The respective quantities of hot and cold water were adjusted until a final temperature of the mixture that is close to the room temperature was obtained. The equation for the heat capacity $\boldsymbol{C}$ of the calorimeter was obtained from the energy balance as shown below (Aviara and Haque, 2001; Razavi and Taghizadeh, 2007)

$$C = \frac{M_{hw}C_w(T_h - T_e)}{(T_e - T_c)} - M_{cw}C_w \qquad (4)$$

Where $\boldsymbol{C}$ is specific heat of the calorimeter (J/kg^{o}C), $\boldsymbol{M_{cw}}$ is the mass of cold water (g), $\boldsymbol{C_w}$is the specific heat of water (J/kg^{o}C), $\boldsymbol{M_{hw}}$is the mass of hot water (g), $\boldsymbol{T_h}$ is the temperature of hot water (^{o}C), $\boldsymbol{T_e}$is the equilibrium temperature while $\boldsymbol{T_c}$ is the temperature of cold water (^{o}C). The calibration was replicated five times while adjusting the quantities of hot and cold water. The average value of the specific heat of the calorimeter was found to be 395.2 J/kg^{o}C with standard deviation of 5.14 J/kg^{o}C.

The specific heats of the samples were obtained by adding a sample of known weight, temperature and moisture content was into the calorimeter containing water of known weight and temperature. The mixture was stirred continuously with the aid of a copper stirrer. The temperature was recorded at an interval of 10s using a K-type thermocouple. At equilibrium, the final temperature was noted and the specific heat was calculated using equation (5) (Aviara and Haque, 2001).

$$C_s = \frac{(M_cC_c + M_wC_w)[T_w - (T_e + t'R')]}{M_s[(T_e + t'R') - T_s]} \qquad (5)$$

Where C_s= Specific heat of sample (J/kg ^{o}C); M_c= Mass of calorimeter (kg); C_c= Specific heat of calorimeter (J/kg ^{o}C); M_s= Mass of sample (kg); M_w= Mass of water (kg); C_w= Specific heat of water (J/kg ^{o}C); T_w, $T_s$and T_e = temperatures of water, sample and at equilibrium respectively.

$R'$is the rate of temperature fall of the mixture after equilibrium (^{o}C) and t' is the time taken for the sample and water mixture to come to equilibrium (s). The term $t'R'$ accounts for the heat of hydration and heat exchange with the surroundings. The experiment was repeated 3 times at each moisture level, and the average values of specific heat are reported.

3.0 RESULTS AND DISCUSSION

Tables 1, 2 and 3 below give the full results of the experiments. It shows the values obtained experimentally for the specified moisture content and temperature ranges. The analysis of variance (ANOVA) was performed on the results to get a better understanding of the effect of the variables on specific heat of the samples. The result of this analysis showed that the influence of these variables on the specific heat of preserved ground sheanut was significant.

Table 1: Specific Heat values of P_1(2.36mm) at Temperature range 50°C – 90°C and Moisture Content 3.26- 40% d.b.

Temp. (°C)	**Moisture content (% d.b.)**				
	3.26	10	20	30	40
	Specific Heat (J/kg °C)				
50	2914.47	2927.20	3722.76	3100.59	4114.67
60	2674.53	3340.95	3226.87	3283.22	3579.76
70	3230.98	3209.00	3412.81	3314.21	3847.72
80	2715.62	2847.27	3480.78	3566.50	4014.27
90	3446.39	3783.93	3392.04	3585.95	4007.75

(Source; Nwannewuihe, 2010)

Table 2: Specific Heat values of P_2(1.18mm) at Temperature range 50°C – 90°C and Moisture Content 3.26- 40% d.b.

Temp. (°C)	**Moisture content % (d.b)**				
	3.26	10	20	30	40
	Specific Heat (J/kg °C)				
50	1952.08	3613.43	3740.86	3943.29	4056.35
60	2021.26	3442.28	3826.37	3650.99	3863.84
70	2545.14	3530.96	3692.41	3882.36	4189.82
80	2636.14	3555.07	3654.73	4129.45	4156.26
90	2944.72	3251.35	3774.34	4151.56	4401.82

(Source; Nwannewuihe, 2010)

Table 3: Specific Heat values of P_3(1.00mm) at Temperature range 50°C – 90°C and Moisture Content 3.26- 40% d.b.

Temp. (°C)	**Moisture content % (d.b)**				
	3.26	10	20	30	40
	Specific Heat (J/kg °C)				
50	2429.05	3385.58	3896.47	3957.56	4343.87
60	2704.46	3325.16	3589.20	3735.89	3649.28
70	2765.46	3532.00	3675.24	4102.32	3962.74
80	2718.87	3364.63	3606.61	4214.75	3710.06
90	2836.73	3412.22	3637.23	3969.03	3969.95

(Source; Nwannewuihe, 2010)

3.1 The Effect of Moisture Content

From the data obtained it was observed that specific heat value increased with increase in moisture content of the samples. For particle size P_1, values of specific heat varied between 2674.53 and 4114.67 J/kg °C with increasing moisture content of the range 3.26 – 40% db. P_2 and P_3 also varied between 1952.08 to 4401.82 and 2429.05 to 4343.87 J/kg °C respectively. This showed lower values at initial moisture content and relatively higher values at other moisture contents.

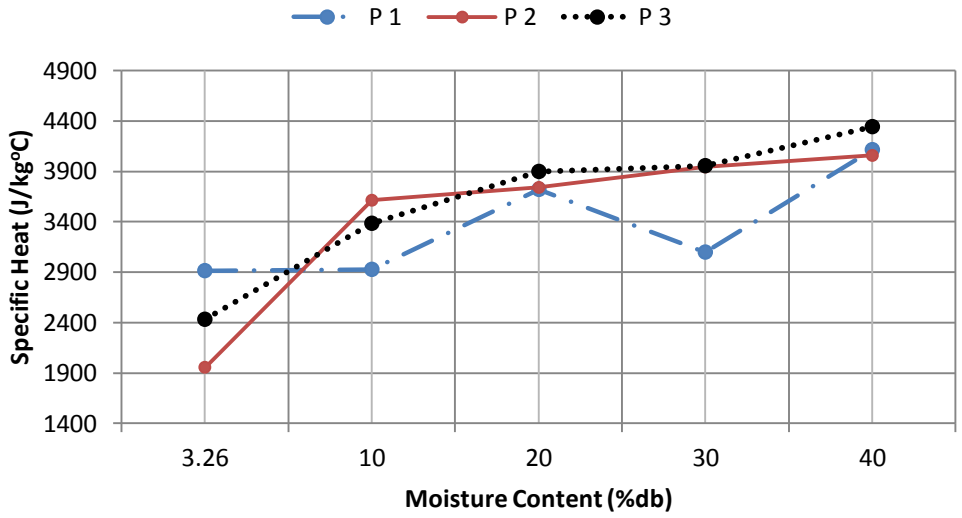


Figure 2: Effect of Particle Size and Moisture Content on Specific Heat of Fresh Ground Sheanut Kernel at 50°C

(Source; Nwannewuihe, 2010)

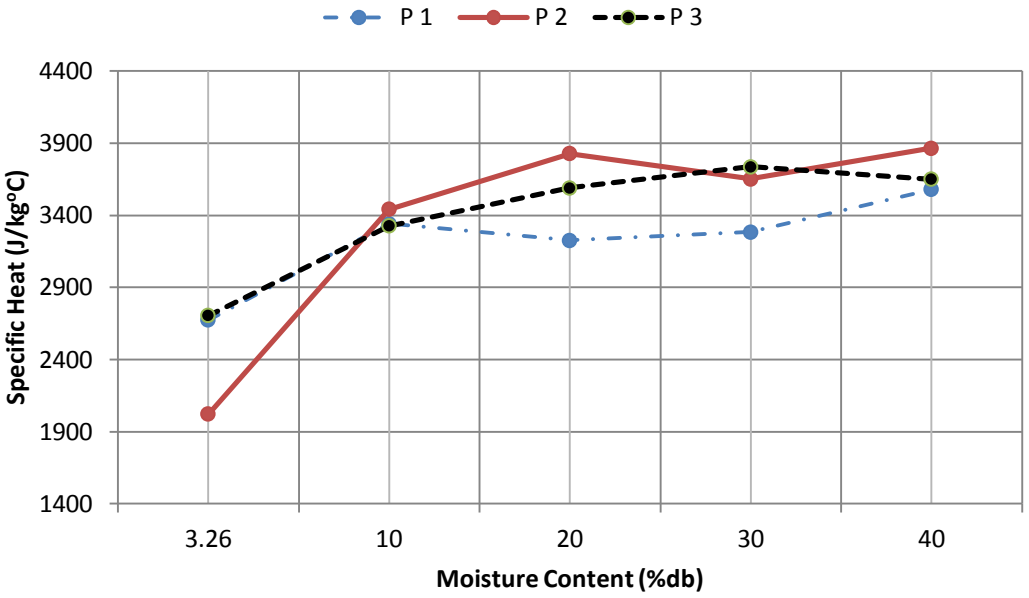


Figure 3: Effect of Particle Size and Moisture Content on Specific Heat of Fresh Ground Sheanut Kernel at 60°C.

(Source; Nwannewuihe, 2010)

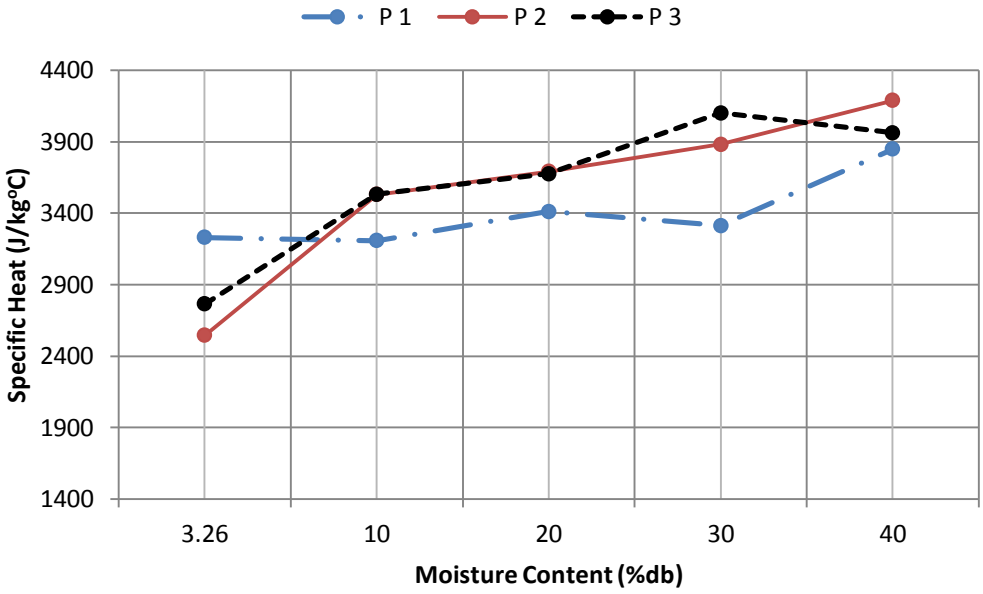


Figure 4: Effect of Particle Size and Moisture Content on Specific Heat of Fresh Ground Sheanut Kernel at 70°C.

(Source; Nwannewuihe, 2010)

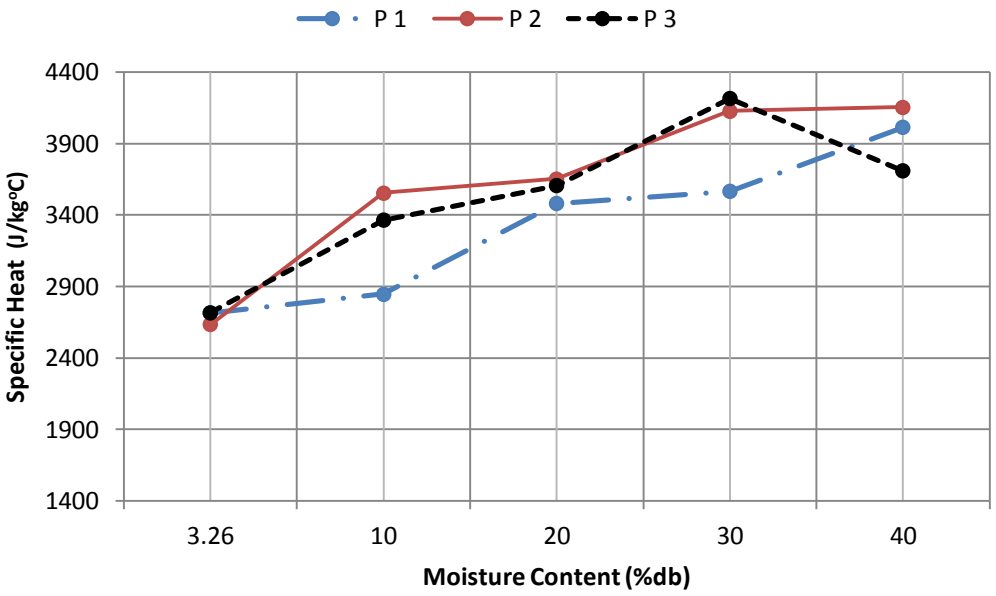


Figure 5: Effect of Particle Size and Moisture Content on Specific Heat of Fresh Ground Sheanut Kernel at 80°C.

(Source; Nwannewuihe, 2010)

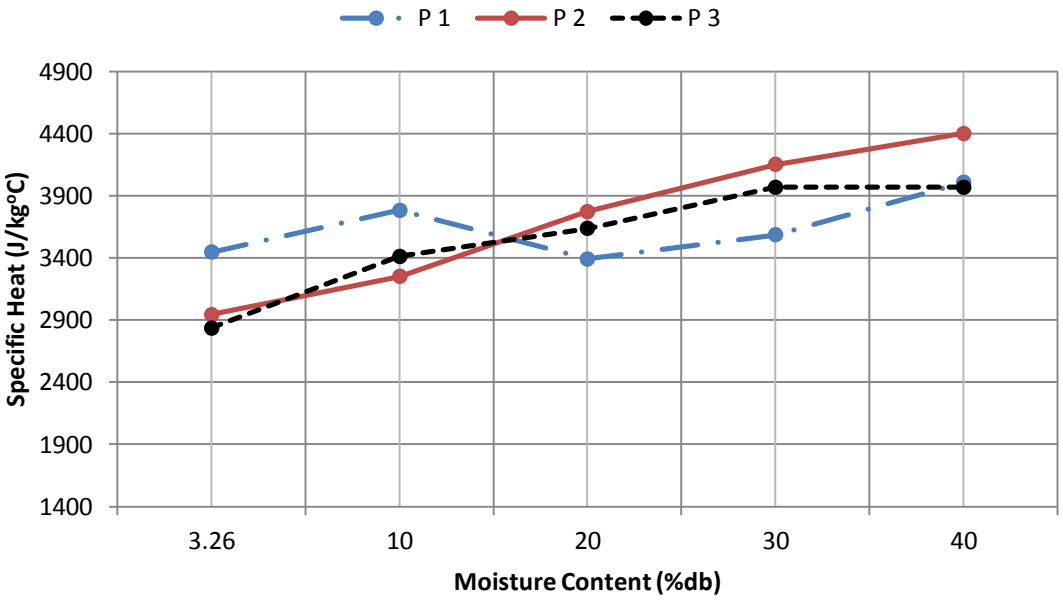


Figure 6: Effect of Particle Size and Moisture Content on Specific Heat of Fresh Ground Sheanut Kernel at 90°C

(Source; Nwannewuihe, 2010)

The relationship between the specific heat and moisture content for each particle size can be best expressed by the following regression equations:

(50 ^{o}C)

P_1 $C_s = 2375.27 + 152.82M – 7.74M^2 + 0.12M^3$ $R^2 = 0.897$ (6)

P_2 $C_s = 920.79 + 387.28M – 15.76M^2 + 0.20M^3$ $R^2 = 0.903$ (7)

P_3 $C_s = 1701.44 + 252.998M – 9.67M^2 + 0.13M^3$ $R^2 = 0.955$ (8)

(60^{o}C)

P_1 $C_s = 2229.01 + 172.57M – 8.25M^2 + 0.12M^3$ $R^2 = 0.903$ (9)

P_2 $C_s = 0.21M^3 – 16.14M^2 + 386.57M + 940.78$ $R^2 = 0.896$ (10)

P_3 $C_s = 0.04M^3 – 3.97M^2 + 129.11M + 2342.52$ $R^2 = 0.914$ (11)

(70^{o}C)

P_1 $C_s = 0.05M^3 – 2.50M^2 + 41.43M + 3087.5$ $R^2 = 0.912$ (12)

P_2 $C_s = 0.13M^3 – 9.62M^2 + 235.69M + 1909.82$ $R^2 = 0.936$ (13)

P_3 $C_s = 0.03M^3 – 3.22M^2 + 123.48M + 2448.6$ $R^2 = 0.925$ (14)

(80^{o}C)

P_1 $C_s = 0.01M^3 – 0.74M^2 + 52.59M + 2507.51$ $R^2 = 0.982$ (15)

P_2 $C_s = 0.06M^3 – 5.34M^2 + 164.15M + 2217.09$ $R^2 = 0.938$ (16)

P_3 $C_s = – 0.05M^3 + 1.64M^2 + 48.62M + 2604.43$ $R^2 = 0.903$ (17)

(90^{o}C)

P_1 $C_s = 0.09M^3 – 5.12M^2 + 79.35M + 3285.27$ $R^2 = 0.886$ (18)

P_2 $C_s = – 0.02M^3 + 0.52M^2 + 43.97M + 2790.7$ $R^2 = 0.992$ (19)

P_3 $C_s = 0.02M^3 – 2.45M^2 + 98.48M + 2570.28$ $R^2 = 0.950$ (20)

From the above, it can be observed that a trinomial relationship exists between the specific heat of ground preserved sheanut kernel and moisture content with the above equations their best fit mathematical models. This was similar to what was reported by Datta*et al.*, 1988 (gram),Razavi and Taghizadeh (2007) for four varieties of Iranian pistachio nutsAremu and Nwannewuihe (2011) for fresh ground sheanut kernel.

However, researchers such a Singh and Goswami, 2000 (cuming seed), Aviara and Haque 2001 (whole sheanut kernel), Yang *et al*., 2002 (borage seeds), Subramanian and Viswanathan, 2003 (minor millet grains and flours) showed that linear relationships existed between the specific heat of the crops studied and moisture content.

3.2 The Effect of Temperature

The results of the values of specific heat of the selected particle sizes at various temperatures are presented in figures 7 – 11. It can be observed from the values obtained thatthe specific heats of the samples increased as temperature increased. It was also observed to decrease with decrease in particle size at storage content (3.26% db). Particle size 1.18mm (P_2) had the highest specific heat value across the temperature range selected. Though variation with temperature was observed, its effects on specific heat were minimal as values were slightly close to one another for all three-particle sizes. Generally, the specific heats of all the particle sizes were in the range of 1952.08 to 4401.82 J/kg ^{o}C. The relationship between the specific heat and temperature was also non-linear and their best fit mathematical models were third order polynomial equations given in equations 21-35 below.

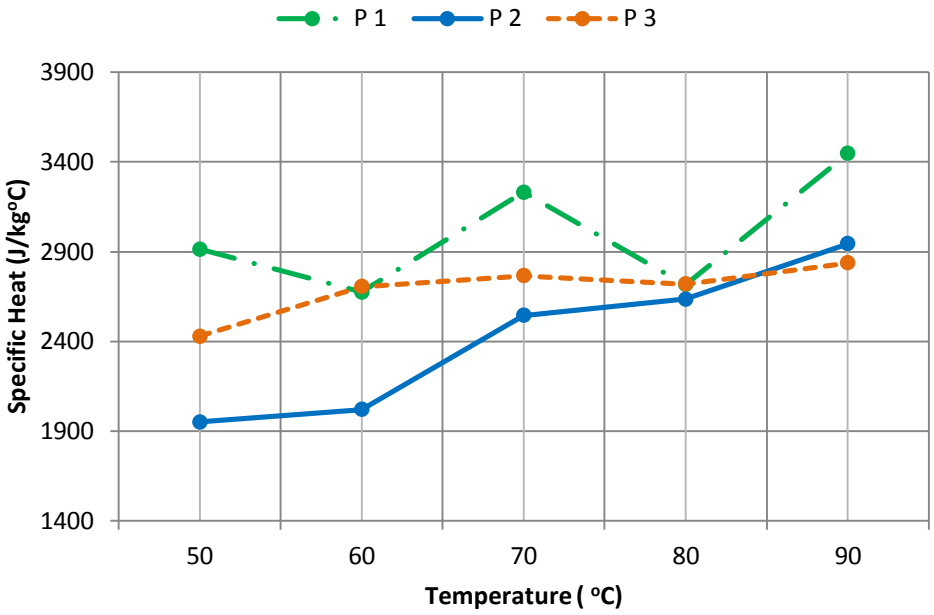


Figure 7: Effect of Particle Size and Temperature on Specific Heat of Ground Sheanut Kernel samples at initial Moisture Content

(Source; Nwannewuihe, 2010)

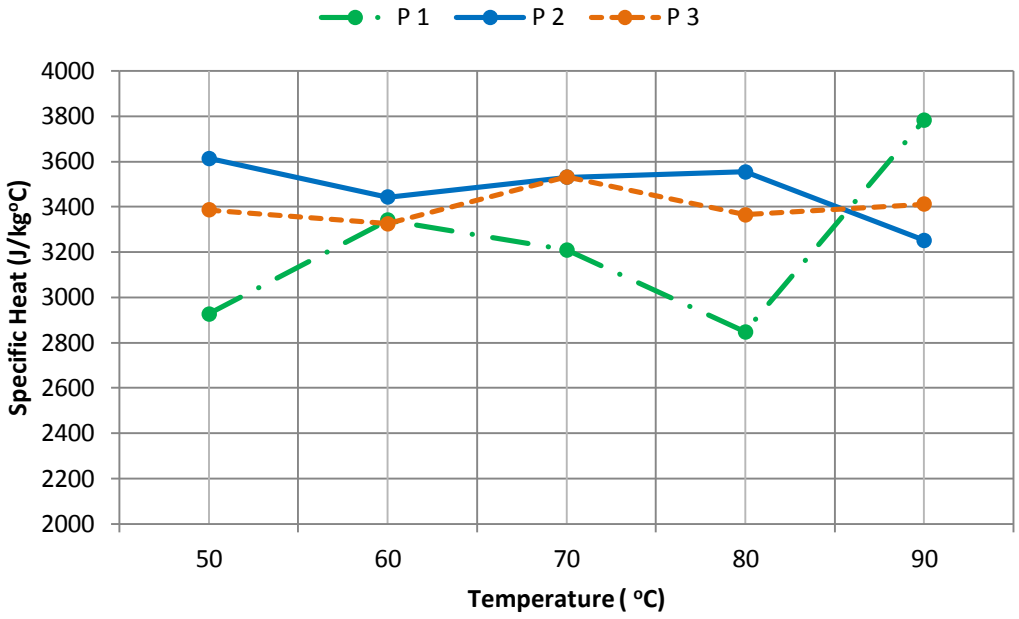


Figure 8: Effect of Particle Size and Temperature on Specific Heat of Ground Sheanut Kernel samples at 10% Moisture Content

(Source; Nwannewuihe, 2010)

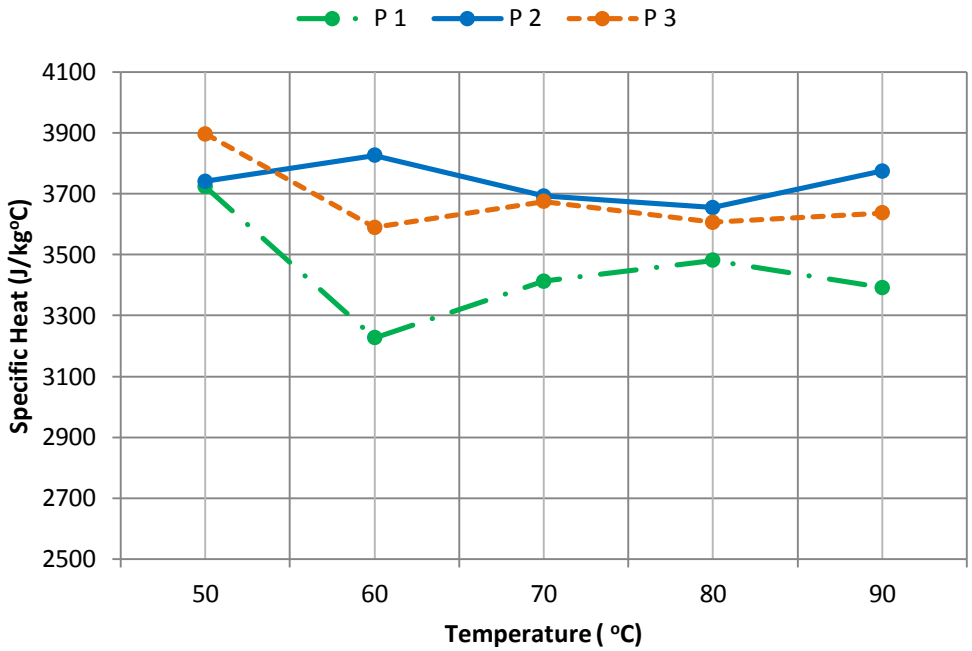


Figure 9: Effect of Particle Size and Temperature on Specific Heat of Ground Sheanut Kernel samples at 20% Moisture Content

(Source; Nwannewuihe, 2010)

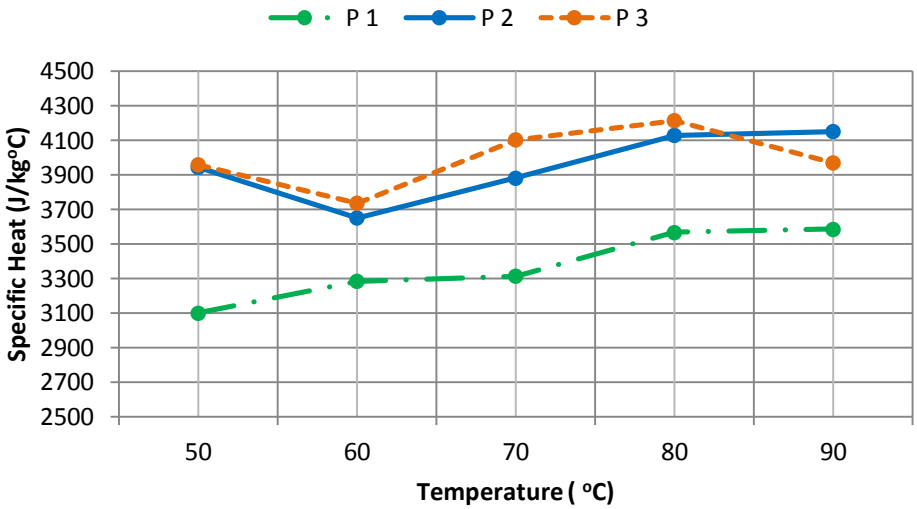


Figure 10: Effect of Particle Size and Temperature on Specific Heat of Ground Sheanut Kernel samples at 30% Moisture Content

(Source; Nwannewuihe, 2010)

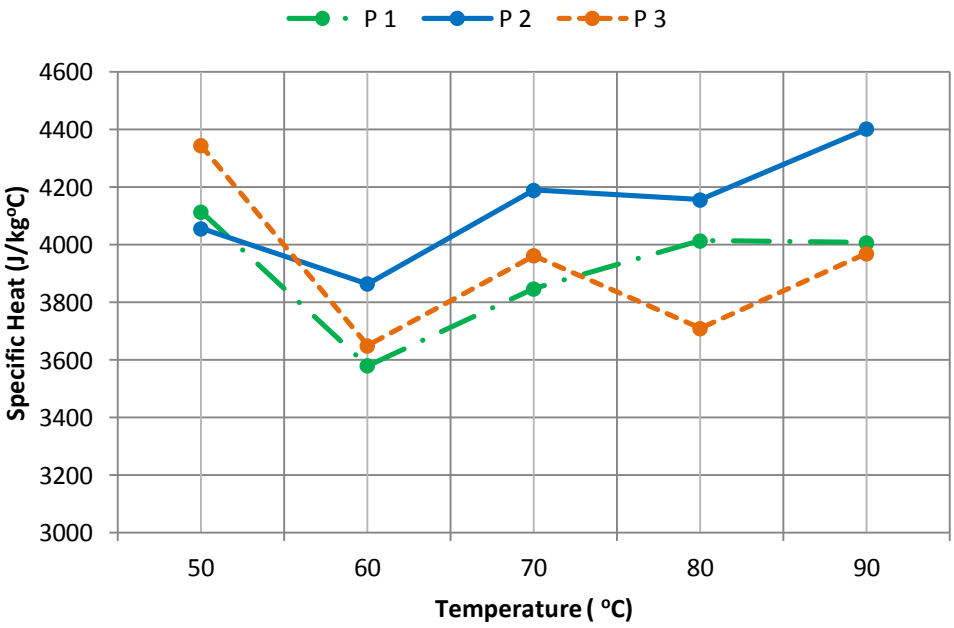


Figure 11: Effect of Particle Size and Temperature on Specific Heat of Ground Sheanut Kernel samples at 40% Moisture Content

(Source; Nwannewuihe, 2010)

The following regression equations express their relationship where 1-5 represent the moisture content range of 3.26 -40 % db.

P_1 (1) $Cs = 0.04T^3 - 7.25T^2 + 462.28T - 6820.73$ ($R^2 = 0.888$) (21)

P_2 (1) $Cs = -0.02T^3 + 4.18T^2 - 262.34T + 7061.3$ ($R^2 = 0.978$) (22)

P_3 (1) $C_s = 0.32T^3 - 6.93T^2 + 503.94T - 9386.63$ ($R^2 = 0.917$) (23)

P_1 (2) $Cs = 0.15T^3 - 31.69T^2 + 2137.36T - 43945.4$ ($R^2 = 0.889$) (24)

P_2 (2) $Cs = -0.05T^3 + 10.05T^2 - 676.38T + 18431.5$ ($R^2 = 0.887$) (25)

P_3 (2) $Cs = -0.004T^3 + 0.80T^2 - 45.84T + 4199.11$ ($R^2 = 0.950$) (26)

P_1 (3) $Cs = -0.07T^3 + 15.17T^2 - 1077.16T + 28375.2$ ($R^2 = 0.912$) (27)

P_2 (3) $Cs = 0.03T^3 - 6.48T^2 + 433.36T - 5658.62$ ($R^2 = 0.936$) (28)

P_3 (3) $Cs = -0.03T^3 + 5.52T^2 - 409.01T + 13603.1$ ($R^2 = 0.885$) (29)

P_1(4) $Cs = -0.01T^3 + 1.35T^2 - 74.12T + 4299.51$ ($R^2 = 0.974$) (30)

P_2 (4) $Cs = -0.06T^3 + 13.56T^2 - 951.39T + 25402.9$ ($R^2 = 0.888$) (31)

P_3(4) $Cs = -0.08T^3 + 16.34T^2 - 1097.12T + 27800.7$ ($R^2 = 0.898$) (32)

P_1 (5) $Cs = -0.08T^3 + 17.76T^2 - 1261.21T + 32925.7$ ($R^2 = 0.955$) (33)

P_2 (5) $Cs = -0.02T^3 + 4.56T^2 - 328.27T + 11546.81$ ($R^2 = 0.902$) (34)

P_3 (5) $Cs = -0.04T^3 + 9.63T^2 - 734.17T + 22098.9$ ($R^2 = 0.905$) (35)

The analysis of variance (ANOVA) done showed that calculated F-values of P_1, P_2 and P_3 were 4.29, 4.45 and 4.51 respectively. This is higher than the tabulated F-value of 2.87 and indicates that at 5% level of significance the observed differences were statistically significant. It was also observed that these calculated F-values increased with increase in particle size.

4.0 CONCLUSIONS

From the above results and analysis it can be concluded that of the three variables investigated (particle size, moisture content and temperature), moisture content had the most direct effect on the specific heat of the preserved ground sheanut kernels. The specific heat increased with increase in moisture content and varied with both particle size and temperature. Particle size P_2 (1.18mm) showed greater variation than P_1 and P_3 and while the effect of temperature was minimal within the range studied. The developed models can be used to estimate the specific heat of preserved ground sheanut kernels satisfactorily under similar conditions.

REFERENCES

Adgidzi, D; Balami, A. A. and Esemikose, R. M. (2003).*Development and performance*

*evaluation of shea butter extraction.*Proceedings of the 4th International Conference of the Nigerian Institution of Agricultural Engineers,25: 251-257.

AOAC, (2002).*Official Methods of Analysis,* 17th Ed. Association of Official Analytical

Chemists, Gaithersburg, Maryland, USA.

Aremu A.K and Nwannewuihe H.U. (2011).*Specific Heat of Ground Fresh Sheanut*

Kernel(Butyrospernumparadoxum) as Affected by Particle Size, Moisture Content and Temperature. Journal of emerging trends in Engineering and applied sciences (JETEAS) Vol. 2 (1): 177 - 183

Aviara, N.A. and Haque,M.A. (2001). Moisture Dependence of Thermal Properties of Sheanut Kernel. *Journal of Food Engineerig.*Elsevier Science Direct. Vol.47: 109-113.

Balasubramanian, D. (2001). Physical Properties of Raw Cashew Nut.*Journal of*

Agricultural Engineering Research. Vol. 78(3): 291 – 297.

Bup N.D, C´esar K, Dzudie.T, Kuitche A, Abi C.F, and Tchi´egang C., (2008).*Variation of*

*the Physical Properties of Sheanut (VitellariaParadoxaGaertn.) Kernels during Convective Drying.*International Journal of Food Engineering. Volume 4, Issue 7, 2008 Article 7

Datta, S K., Nema, V. K., and Bhardwaj, R.K. (1988).Thermal properties of gram.*Journal*

of Agricultural Engineering Research. 39 (4). 269-275

Hall J.B, Aeibisher D.P, Tomlinson H.F, Osei-Amaning E, Hindle J.R (1996).*Vitellaria*

*paradoxa, a monograph Project B 4850.*Forestry Research Programme.School of Agricultural Science, University of Wales, Banger, U.K. p. 105.

Irtwange S.V (2000). *The effect of accession on some physical and engineering properties of African yam bean.* Unpublished PhD Thesis, Department of Agricultural Engineering, University of Ibadan, Nigeria

Mohsenin, N.N. (1980). *Thermal properties of foods and agricultural materials.*1st Edn.*New* York, Gordon and Breach.

Nwannewuihe, H.U. (2010). *Effects of particle size, moisture content and temperature on*

the thermal properties of ground sheanut kernel. Unpublished M.Sc Dissertation, Department of Agricultural Engineering, University of Ibadan, Nigeria

Olaniyan, A.M. and Oje, K. (2002).Some Aspects of the Mechanical Properties of Shea Nut.*Biosystem Engineering*. Vol. 81(4): 413 – 420.

Oluwole F.A., Aviara N.A. and Haque, M.A., (2004),*Development and Performance Test of*

*aSheanut Cracker.*Journal of food Engineering, 65, 117-123.

Opoku Anthony, Lope G. Tabil, Bill Crerar and Mark D. Shaw, (2004). Thermal

Properties of Timothy Hay. Paper number 046130, 2004 ASAE Annual Meeting.

Razavi, S.M.A. and Taghizadeh, M. (2007). The Specific Heat of Pistachio Nuts as affected by Moisture Content, Temperature and Variety. *Journal of Food Engineering.*Elsevier Science Direct. Vol.79:158–167.

Shrivastava, M. and Datta, A.K. (1999). Determination of Specific Heat and Thermal Conductivity of Mushrooms (*Pleu-rotusflorida*). *Journal of Food Engineering.*Elsevier Science Direct. Vol. 39: 255 – 260.

Singh, K.K. and T.K. Goswami, (2000).*Thermal Properties of Cumin Seed.* Journal of

Food Engineering, 45:181- 187.

Sreenarayanan, V.V. and P.K. Chattopadhyay, (1986).*Specific Heat of Rice Bran.*Agric. Wastes, 16: 217–224.

Subramanian, s. and R. Viswanathan.(2003). *Thermal Properties of Minor Millet Grains and* Flours.Biosystems Engineering, 84 (3): 289-296.

Tabil, L. G., (1999). *Specific Heat of Agricultural and Food Materials.* Research report,

Department of Agricultural and Bio-resource Engineering, University of Saskatchewan, Canada.

Yang .W, Sokhansanj .S, Tang .J, and Winter .P (2002). Determination of thermal

conductivity, specific Heat and thermal conductivity of borage seeds. *Biosystem Engineering*. Vol. 82(2): 169 – 176

Wiemer, H. and Korthals, F. W. (1989).*Small-scale processing of oil fruits and oil seeds*.

Friedr.Vieweg and sohnverlagshgesell-schaffmbh, Braunschweig, Germany.

SPEED BASED PERFORMANCE TRENDS FOR A CENTRIFUGAL HULLER DEVELOPED FOR SUNFLOWER SEEDS

Abubakar, L.G. and Akangbe, O.L.

Agricultural Engineering Programme, Abubakar Tafawa Balewa University, Bauchi, Nigeria.
lawanabubakar@ymail.com

ABSTRACT

A procedure for evaluating single factor polynomial forms for equipment performance using methods of the analysis of variance applicable to experiments run at unequal treatment intervals was applied for generating speed based performance trends for a centrifugal type sunflower seed huller. Performance tests on the huller were carried out at varying impeller peripheral speeds. The best predictor for hulling efficiency was found to be a cubic trend in speed. Kernel breakage trend was parabolic. The study revealed that variations in hulling performance can be satisfactorily estimated using the generated trends ($R^2 = 0.999$, for hulling efficiency and $R^2 = 0.997$, for kernel breakage). The result is of significance in selecting speeds for equipment design and optimum performance. These results are valid within the 1561 – 3053 $mmin^{-1}$ impeller peripheral speed range.

Keywords: Speed, Hulling Efficiency, Breakage, Sunflower

1. Introduction

Sunflower is an important world oilseed. The traditional problem associated with the sunflower industry is the hulling of sunflower seeds. Hulling involves separating the whitish kernel of the sunflower seed from its enclosing hull. A number of techniques are usually employed to hull sunflower seeds. These common methods are based on any of two identified principles namely, impact and shear.Attrition has been employed in hulling by passing seeds between two discs, one rotating and the other stationary (Beaumont, 1980 and Hussain et al., 1980). In impact hulling, either the seed is directly impacted upon by a rotating drum or it is made to move at very high velocities while being directed against a hard surface on which it makes impact. Such high velocities have been achieved by either conveying the seed in high velocity airstreams (Nolasco et al., 2002) or by centrifugation using rotating impellers with vanes of varying configurations (Nag et al., 1983, Yadav et al., 1996 and Amuthan et al., 2001). Impact by centrifugation is the most popular of these techniques(Senkoylu et al., 1999). However, seed hulling has not been totally successful(Senkoylu et al., 1999), particularly because of the nature of the high oilseed sunflower seeds; poor hulling performances have been suggested to be a function of pericarp structures and thetight binding nature of the hull to the kernel in high oil content sunflower seeds(Senkoylu et al., 1999 and Denis et al., 1994). Betterhulling performances have been associated with hulling speed; speed has been reported to be the most important single factor influencing hulling performance (Nag et al., 1983 and Mohammed et al., 2011). The objective of this study was to establish a speed based relationship for hulling performance in a centrifugal type huller for sunflower seeds using simple linear regression techniques.

Single factor relations provide quick means for evaluating the performance of equipments which are under development and for specifying optimum performance settings. The performance of an equipmentcan be evaluated by observing its behavior at different levels of an influencing factor.

Influence factors are many and differ for equipment types. Recommended practice involves varying such factors at equal intervals to observe the machine's performance. However, it is not uncommon to encounter situations where it is difficult to vary a factor of study at equal intervals. This study presents a method for fitting polynomial trends to equipment performance data of unequal treatment intervals using single degree of freedom orthogonal contrast coefficients. The appropriateness or otherwise of a polynomial in estimating the performance of the equipment is justified using the method of the analysis of variance.

2. MATERIALS AND METHODS

2.1. Equipment Description

The equipment studied is a centrifugal type sunflower seed huller with a twin hulling unit (Fig.1). Seed hulling is achieved in this machine by subjecting the seeds to high centrifugal forces using rotating impellers and directing the seeds against hard surfaces of impact (Akangbe, 2006).

2.2. Experimental Design

The performance of the machine on the Funtua variety of sunflower seeds was evaluated at five impeller peripheral speed treatment levels (1561, 1955, 2349, 2659 and 3053 m min^{-1}). This was done using radial vane impellers with 0° vane angle, with respect to the vane radius, at 79 kgh^{-1} product feed rate, by gravity, and at 5% product moisture content, in dry basis. The material of the impact surface was 3mm thick mild steel plate. These tests were conducted in three repetitions, giving a total of 15 experimental runs. The experiment was considered as a completely randomized design. The machine's performancesof interest were hulling efficiency and kernel breakage, evaluated as follows:

$$\eta_H = 100\left(1 - \frac{Q_U}{Q_O}\right) \quad (1)$$

$$\eta_H = 100\left(\frac{Q_B}{Q_O}\right) \quad (2)$$

Where, η_B = Kernel Breakage (%)

η_H = Hulling efficiency (%)

Q_B = Quantity of broken kernels, g

Q_O = Quantity of products collected at outlets, g

Q_U = Quantity of unhulled seeds, g

2.3. Data Analysis

Polynomial regression trends were fitted to the hulling performance data obtained at varying levels of speed for the different levels of the other influencing factors studied, using the method of orthogonal polynomials described by Ahmed, Gomez and Gomez and Little and Hill(Ahmed, 1997, Gomez and Gomez, 1984 and Little and Hills, 1978). The best trend was obtained as one with at least a significant effect and a non-significant deviation from trend. All computations were done using the MS Excel and Polymath Edusoftware.

Hulling efficiencies observed during the performance tests conducted are presented in Table 1.

A total sum of squares (TSS) for the data set was computed as:

$$TSS = \sum \eta_i^2 - \frac{\sum \eta_i}{n}; \qquad i = 1,2,\dots,15 \tag{3}$$

Where, η_i= i^{th}observation and

n = number of observations

A corrected sum of squares was computed as follows to evaluate the effect of the treatment or main factor of study (that is, speed):

$$SS_{SPEED} = \sum\left(\sum \eta_j\right)^2 - \frac{\sum \eta_i}{n}; \qquad i = 1,2,\dots,15 \tag{4}$$

Where, $\sum\eta_j$ = sum of observations for the j^{th} treatment. The treatment levels are the five speed settings 1561, 1955, 2349, 2659 and 3053 m min^{-1}.

Subtracting the treatment or speed sum of squares (SS_{SPEED}) from the total sum of squares gives the Error Sum of Square (*ESS*).

The procedure for deriving orthogonal polynomial coefficients for treatments having unequal treatment intervals has been described by Gomez and Gomez[12]. A set of codes (X) were obtained by dividing the five speed/treatment levels through by the lowest speed value and simplifying appropriately (Table 2).

Thesecodes were used to compute orthogonal polynomial coefficients specific to the speed intervals in this study as follows:

$$C_{L_i} = \alpha + X_i \quad , \qquad \text{for the linear form} \tag{5}$$

Where, C_{L_i} is the i^{th} linear orthogonal polynomial coefficient

$X_i$is the i^{th} code (Table 2).

$$\propto = -\frac{\sum X}{t} \tag{6}$$

t = number of treatments

t = 5

$$C_{Q_i} = \beta + \gamma X_i + X_i^2, \qquad \text{for the quadratic form} \tag{7}$$

Where, C_{Q_i} is the i^{th} orthogonal coefficient for the quadratic polynomial form

$$\beta = \frac{(\sum X)(\sum X^3)-(\sum X^2)^2}{t(\sum X^2)-(\sum X)^2} \quad (8)$$

$$\gamma = \frac{(\sum X)(\sum X^2)-t(\sum X^3)}{t(\sum X^2)-(\sum X)^2} \quad (9)$$

$$C_{C_i} = \delta + \varepsilon X_i + \zeta X_i^2 + X_i^3 \quad , \quad \text{for the cubic form} \quad (10)$$

Where, C_{C_i} is the i^{th} orthogonal coefficient for the cubic polynomial form

$$\zeta = \frac{\sum X^5[(\sum X)^2-t(\sum X^2)]+\sum X^4[t\sum X^3-(\sum X)(\sum X^2)]+\sum X^3[(\sum X^2)^2-(\sum X)(\sum X^3)]}{\sum X^4[t\sum X^2-(\sum X)^2]+\sum X^3[(\sum X)(\sum X^2)-t\sum X^3]+\sum X^2[(\sum X)(\sum X^3)-(\sum X^2)^2]} \quad (11)$$

$$\varepsilon = \frac{\zeta[(\sum X)(\sum X^2)-t(\sum X^3)]+[(\sum X)(\sum X^3)-t(\sum X^4)]}{t\sum X^2-(\sum X)^2} \quad (12)$$

$$\delta = -\frac{\varepsilon(\sum X)+\zeta(\sum X^2)+\sum X^3}{t} \quad (13)$$

The orthogonal polynomial coefficients generated are presented in Table 3 as C_L, C_Q and C_C for the linear, quadratic and cubic polynomials, respectively.

Products of mean performance and respective orthogonal coefficients at each treatment level were obtained for each degree polynomial as $\bar{\eta}C_L$, $\bar{\eta}C_Q$ and $\bar{\eta}C_Q$ for the first, second and third degree polynomials, respectively; sums of products P_L, P_Q and P_C, for linear, quadratic and cubic forms, respectively, were obtained as $\sum\bar{\eta}C_L$, $\sum\bar{\eta}C_Q$ and $\sum\bar{\eta}C_C$, respectively (Table 3). The sums of the squares of orthogonal polynomial coefficients were also obtained as $\sum C_L^2$, $\sum C_Q^2$ and $\sum C_C^2$, for the linear, quadratic and cubic forms, respectively (Table 3).

Sums of squares of the different degrees of polynomials were obtained as:

$$SS_L = \frac{P_L^2}{Rep\times\sum C_L^2} \quad (14)$$

$$SS_Q = \frac{P_Q^2}{Rep\times\sum C_Q^2} \quad (15)$$

$$SS_C = \frac{P_C^2}{Rep\times\sum C_C^2} \quad (16)$$

Where, SS_L, SS_Q and SS_C = sums of squares for linear, quadratic and cubic trend forms, respectively.

Rep = number of repetitions

Rep = 3

Little and Hill [13] describe a general procedure for generating polynomial trend forms for a data set, as applied below. Transforms of speed/treatment levels and products of transforms and mean performances were generated as presented in Table 4.

The linear polynomial form is:

$$\eta = a + bS \tag{17}$$

The intercept 'a' and the slope coefficient 'b' were generated from the following linear relationships:

$$an + b\sum S = \sum \bar{\eta} \tag{18}$$

$$a\sum S + b\sum S^2 = \sum \bar{\eta} S \tag{19}$$

Where, $\sum \bar{\eta}$ = sum of mean performances, and

$\sum \bar{\eta} S$ = sum of products of mean performances by treatment

The quadratic form is:

$$\eta = a + bS + cS^2 \tag{20}$$

The constants a, b and c were generated from the following linear relationships:

$$an + b\sum S + c\sum S^2 = \sum \bar{\eta} \tag{21}$$

$$a\sum S + b\sum S^2 + c\sum S^3 = \sum \bar{\eta} S \tag{22}$$

$$a\sum S^2 + b\sum S^3 + c\sum S^4 = \sum \bar{\eta} S^2 \tag{23}$$

The cubic form is:

$$\eta = a + bS + cS^2 + dS^3 \tag{24}$$

The constants a, b, c and d were generated from the following linear relationships:

$$an + b\sum S + c\sum S^2 + d\sum S^3 = \sum \bar{\eta} \tag{25}$$

$$a\sum S + b\sum S^2 + c\sum S^3 + d\sum S^4 = \sum \bar{\eta} S \tag{26}$$

$$a\sum S^2 + b\sum S^3 + c\sum S^4 + d\sum S^5 = \sum \bar{\eta} S^2 \tag{27}$$

$$a\sum S^3 + b\sum S^4 + c\sum S^5 + d\sum S^6 = \sum \bar{\eta} S^3 \tag{28}$$

The constants a, b, c and d were generated for each trend form on the Polymath platform using the linear equations solver.

Linear, quadratic and cubic forms obtained for hulling efficiency are:

$$\boldsymbol{\eta} = -2.832024 + 0.0265615\boldsymbol{S} \quad (29)$$

$$\boldsymbol{\eta} = -73 + 0.0909426\boldsymbol{S} - 0.00001398\boldsymbol{S}^2 \quad (30)$$

$$\boldsymbol{\eta} = 23.79015 - 0.0431014\boldsymbol{S} + 0.00004576\boldsymbol{S}^2 - 0.000000008611\boldsymbol{S}^3 \quad (31)$$

These forms were inputed appropriately to generate values of expected performances at each treatment level for each of the polynomial trend forms (Table 5).

Deviations from linearity (d_L) were obtained as:

$$d_L = \bar{\eta} - \eta_L \quad (32)$$

Deviations from quadratic trend (d_Q) were obtained as:

$$d_Q = \bar{\eta} - \eta_Q \quad (33)$$

Deviations from cubic trend (d_C) were obtained as:

$$d_C = \bar{\eta} - \eta_C \quad (34)$$

Where, $\bar{\eta}$ = mean of observed values of machine performance

η_L, η_Q and η_C = expected performances from linear, quadratic and cubic trends, respectively.

Each sum of deviations ($\sum d_L, \sum d_Q$ or $\sum d_C$) is zero (0) except for rounding errors. This is a check and confirms that the computations are in order.

Sums of squares of deviations from trend were computed as $\sum d_L^2$, $\sum d_Q^2$ and $\sum d_C^2$ for the linear, quadratic and cubic trend forms, respectively (Table 5). A further check is that each added degree of polynomial results in a reduction of the sum of squares (Table 6).

Critical variance ratios (F_c) for comparison were read from statistical tables at the indicated treatment/model and error degrees of freedom. A coefficient of determination for each trend form wasobtained by specifying intercepts on the MS Excel platform; specified intercepts are those generated in equations 29 – 31 and 35 – 37.

3. RESULTS AND DISCUSSION

Equations 29 – 31 and Table 6 are results of the curve fitting analyses for hulling efficiency. The linear trend has a highly significant effect in predicting hulling efficiency. However, significant

deviations from this trend were observed (Table 6). As such, this model is not suitable for predicting hulling efficiency. The parabolic form (Equation 30) has highly significant effect in predicting hulling efficiency and deviations from this trend are not significant (Table 6); the model can be considered as a predictor for hulling efficiency. However, this was not the highest degree polynomial with a significant effect in predicting hulling efficiency. The effect of the third degree polynomial (Equation 31) in predicting hulling efficiency is highly significant and deviations from this trend are not significant (Table 6). As such, the cubic trend (Equation 31) was selected as the best fitting curve and predictor for hulling efficiency, being the highest degree polynomial with significant effect in predicting the machine's behavior and insignificant deviations from this trend (Table 6). The coefficient of determination for this model is R^2 = 0.999.

Results of curve fitting analyses for kernel breakage are presented below (Equations 35 – 37 and Table 7). Linear, quadratic and cubic forms obtained for kernel breakage are:

$$\boldsymbol{\eta} = -32.88782 + 0.0248333\boldsymbol{S} \quad (35)$$

$$\boldsymbol{\eta} = -73.37403 + 0.061901\boldsymbol{S} - 0.000008048\boldsymbol{S}^2 \quad (36)$$

$$\boldsymbol{\eta} = -55.10853 + 0.0366446\boldsymbol{S} + 0.000003208\boldsymbol{S}^2 - 0.000000001622\boldsymbol{S}^3 \quad (37)$$

The quadratic form is the highest degree polynomial with a significant effect in predicting kernel breakage; the effect is highly significant and deviations from this trend are not significant (Table 7). As such, Equation 36 was selected as the best predictor for kernel breakage. The coefficient of determination for the trend is R^2 = 0.997. Graphical plots of hulling efficiency and kernel breakage trends are presented in Figure2. Both hulling efficiency and kernel breakage increased with increasing impeller peripheral speed.

4. CONCLUSION

A procedure for fitting single factor polynomial trend forms to hulling performance data in a centrifugal type sunflower seed huller has been presented. A cubic trend (Equation 31) was found to be the most appropriate predictor of hulling efficiency, given significant trend/model effect and insignificant deviations from trend. As high as 99.9 percent of the systems behavior for hulling efficiency is predictable using this model, within the indicated speed range of 1561 – 3053 m min^{-1}. A parabolic form (Equation 36) was found to be the most suitable predictor for kernel breakage. These results are valid for mild steel impact surface, radial vane impellers, 79 kg h^{-1} product feed rate, 5% product moisture content, in dry basis, and within the 1561 – 3053 m min^{-1} impeller peripheral speed range.

5. AKNOWLEDGMENT

This study was partly financed by the Institute for Agricultural Research, IAR Samaru, Zaria, Nigeria.

REFERENCES

Ahmed, M. K. 1997. Polynomial response technique to select the best fitting curve to a given data. Paper presented at the *Special Seminar in Statics*, Department of Agronomy, Ahmadu Bello University, Zaria, Nigeria. May 2.

Akangbe, O. L. 2006. Development and performance evaluation of a centrifugal dehuller for sunflower seeds.M.Sc. thesis, Ahmadu Bello University, Zaria, Nigeria.

Amuthan, G., P. Subramanian, and P.T. Palaswami. 2001. Modifications made on a centrifugal paddy sheller for sunflower seed shelling. *Agricultural Mechanization in Asia, Africa and Latin America* 32(3): 51-53.

Beaumont, J. H. (1980). *A Hand Operated Disc Mill for Decorticating Sunflower Seeds*. Rural Technology Guide No 10. Tropical Product Institute, U.K.

Denis, L., V. Coelho and F. Vear. 1994. Pericarp structure and hullability in sunflower inbred lines and hybrids.*Agronomie*14: 453-461.

Gomez, K. A. and A. A. Gomez. 1984. Statistical procedures for agricultural research, 2ed. New York: John Wiley and Sons.

Hussain, A.A.M., M.A. Sabur and M.M. Rahman (1980). Design and construction of a manually operated castor bean cum sunflower dehuller. *Agricultural Mechanization in Asia, Africa and Latin America,* 11(2): 83-84

Little, T. M. and F. J. Hills. 1978. Agricultural Experimentation. New York: John Wiley and Sons, Inc.

Mohammed, U.S., V.I.O. Ndirika, L.G. Abubakar and O.L. Akangbe. 2011. Predicting Performance in a Centrifugal Sunflower Seed Huller Using Forward-Stepwise Regression Technique. N.S.E. Technical Transactions (In Press).

Nag, K. N., P. Singh and R. Bhandari. 1983. A centrifugal impeller- type of sunflower seed decorticator. *Agricultural Mechanization in Asia, Africa and Latin America* 14(1): 55-58.

Nolasco, S. M., I. C. Riccobene and M. B. Fernandez. 2002. Dehulling of high oil sunflower seed grown in Argentina. Paper presented at the 2002 Annual General Meeting of the American Society of Agricultural Engineers, ASAE.

Senkoylu, N. and N. Dale (1999). Sunflower meal in poultry diets: a review. *World's Poultry Science Journal,* 55: 153-174.

Yadav, R., P. Singh and G. Tiwani. 1996. Studies on centrifugal decortication of sunflower seed. *Agricultural Mechanization in Asia, Africa and Latin America* 27 (3): 62-64.

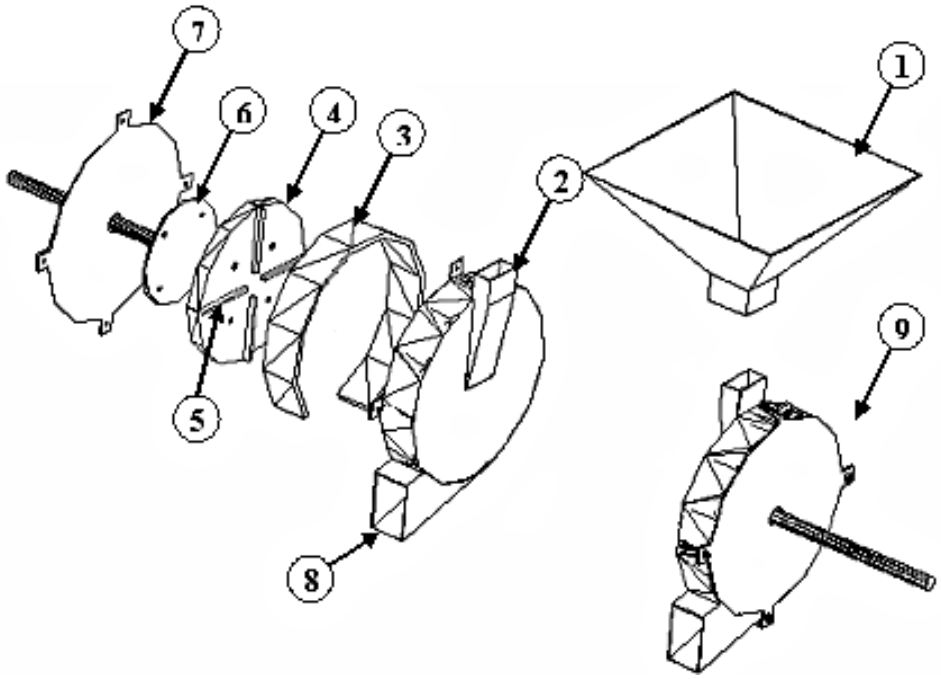


Figure 1: Exploded isometric view of the hulling unit of the sunflower hulling machine showing the hopper (1), chute (2), impact ring (3), impeller disc (4), impeller vane (5), impeller hub (6), cover plate (7), product ejection spout (8) and twin hulling unit (9).

Table 1: Hulling efficiencies at five speed treatment levels

	Speed (m min^{-1})				
Rep	**1561**	**1955**	**2349**	**2659**	**3053**
I	36.5	48.8	65.7	69.0	75.4
II	33.9	49.1	65.0	70.1	74.7
III	35.9	50.9	61.3	72.7	71.0
$\sum \eta_j$	106.3	148.7	192.0	211.8	221.1

Table 2: Codes (X) for generating orthogonal polynomial coefficients

Speed/Treatment Level	**Code (X)**
1561	28
1955	35
2349	42
2659	48
3053	55

Table 3: Mean equipment performances and products of performance by polynomial coefficients

S	$\bar{\eta}$	C_L	$\bar{\eta}C_L$	C_Q	$\bar{\eta}C_Q$	C_C	$\bar{\eta}C_C$
1561	35.4	-14	-1438.4	89	9497.3	-349	-37132.7
1955	49.6	-6	-961.5	-49	-7255.6	758	112709.2
2349	64.0	1	115.7	-87	-16712.5	-62	-11890.7
2659	70.6	6	1305.6	-47	-9933.5	-678	-143711.3
3053	73.7	13	2925.6	93	20643.4	332	73381.5
		P_L =	1947.1	P_Q =	-3760.8	P_C =	-6644.0
	$\sum C_L^2$ =	438	$\sum C_Q^2$ =	28850	$\sum C_C^2$ =	1270552	

Table 4: Transforms and products of transforms and performance

			Speed Transforms					Products		
	S	$\bar{\eta}$	$\mathbf{S^2}$	$\mathbf{S^3}$	$\mathbf{S^4}$	$\mathbf{S^5}$	$\mathbf{S^6}$	$\bar{\eta}\mathbf{S}$	$\bar{\eta}\mathbf{S^2}$	$\bar{\eta}\mathbf{S^3}$
	1561	35.4	2.44×10^{6}	3.80×10^{9}	5.94×10^{12}	9.27×10^{15}	1.45×10^{19}	5.53×10^{4}	8.63×10^{7}	1.35×10^{11}
	1955	49.6	3.82×10^{6}	7.47×10^{9}	1.46×10^{13}	2.86×10^{16}	5.58×10^{19}	9.69×10^{4}	1.89×10^{8}	3.70×10^{11}
	2349	64.0	5.52×10^{6}	1.30×10^{10}	3.04×10^{13}	7.15×10^{16}	1.68×10^{20}	1.50×10^{5}	3.53×10^{8}	8.30×10^{11}
	2659	70.6	7.07×10^{6}	1.88×10^{10}	5.00×10^{13}	1.33×10^{17}	3.53×10^{20}	1.88×10^{5}	4.99×10^{8}	1.33×10^{11}
	3053	73.7	9.32×10^{6}	2.85×10^{10}	8.69×10^{13}	2.65×10^{17}	8.10×10^{20}	2.25×10^{5}	6.87×10^{8}	2.10×10^{12}
$\sum$	11577	293.3	2.82×10^{7}	7.15×10^{10}	1.88×10^{14}	5.08×10^{17}	1.40×10^{21}	7.15×10^{5}	1.82×10^{9}	4.76×10^{12}

Table 5: Observed and expected performances of different polynomials and their deviations

S	$\bar{\eta}$	η_L	$\eta_L - \bar{\eta}$	η_Q	$\eta_Q - \bar{\eta}$	η_C	$\eta_C - \bar{\eta}$
1561	35.4	38.6	3.20	34.7	-0.69	35.3	-0.17
1955	49.6	49.1	-0.48	51.2	1.63	50.1	0.51
2349	64.0	59.6	-4.45	63.3	-0.68	63.4	-0.59
2659	70.6	67.8	-2.82	69.8	-0.79	70.8	0.22
3053	73.7	78.3	4.55	74.2	0.48	73.7	-0.03
		$\sum d_L$ =	0.00	$\sum d_Q$ =	-0.04	$\sum d_C$ =	-0.05
		$\sum d_L^2$ =	58.9	$\sum d_Q^2$ =	4.46	$\sum d_C^2$ =	0.68

Table 6: ANOVA for hulling efficiency

SOURCE	***DF***	***SS***	***MS***	***F***
SPEED	4	3060.0	765.0	214.5^{HS}
LINEAR	1	2883.3	2883.3	808.5^{HS}
DEV. FROM LINEAR	3	58.9	19.6	5.5^{S}
QUADRATIC	1	163.4	163.4	45.8^{HS}
DEV. FROM QUADRATIC	2	4.5	2.2	0.62^{NS}
CUBIC	1	11.6	11.6	17.08^{HS}
DEV. FROM CUBIC	1	0.68	0.68	0.19^{NS}
ERROR	10	35.7	3.57	
TOTAL	14	3095.7		

HS = Highly Significant Effect, at the 0.01 probability level; S = Significant Effect, at the 0.05 probability level; NS = Non-Significant Effect, at the 0.05 probability level.

Table 7: ANOVA for kernel breakage

SOURCE	***DF***	***SS***	***MS***	***F***
SPEED	4	2582.1	645.5	198.8^{HS}
LINEAR	1	2520.3	2520.3	776.3^{HS}
DEV. FROM LINEAR	3	20.6	6.9	2.1^{NS}
QUADRATIC	1	54.2	54.2	16.7^{HS}
DEV. FROM QUADRATIC	2	2.6	1.3	0.39^{NS}
CUBIC	1	0.4	0.4	0.16^{NS}
DEV. FROM CUBIC	1	2.43	2.43	0.75^{NS}
ERROR	10	32.5	3.25	
TOTAL	14	2614.6		

HS = Highly Significant Effect, at the 0.01 probability level; S = Significant Effect, at the 0.05 probability level; NS = Non-Significant Effect, at the 0.05 probability level.

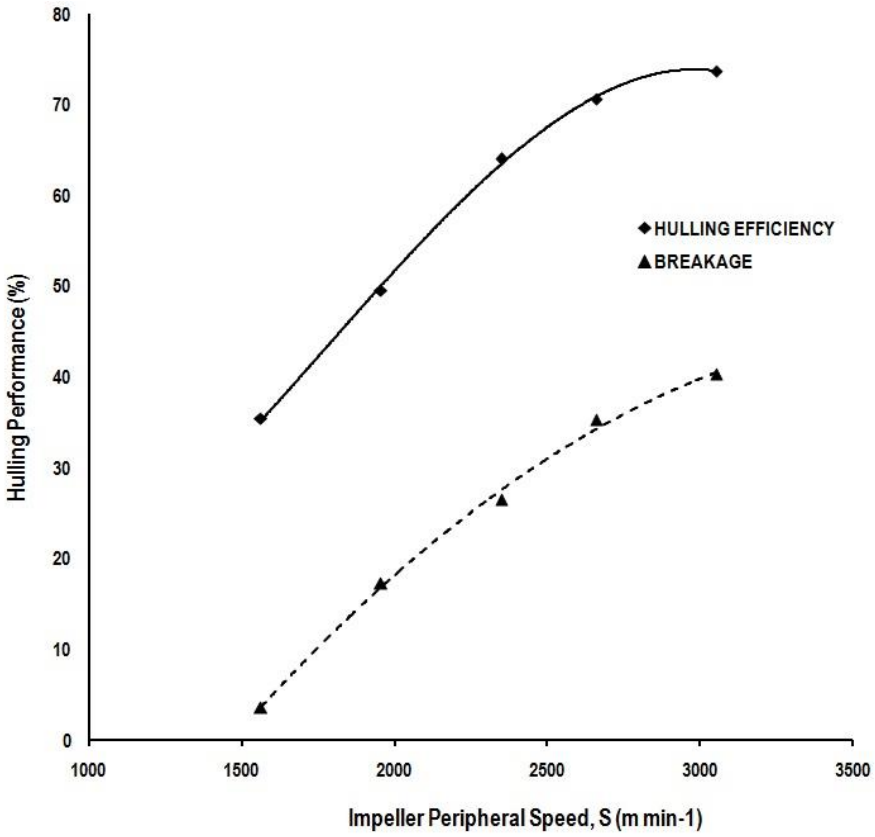


Figure 2: Hulling efficiency and kernel breakage trends on the mild steel impact surface at 79 kg/h product feed rate using a radial impeller vane orientation

EFFECT OF SOME PHYSICO-MECHANICAL PROPERTIES ON MECHANICAL PEELING OF CASSAVA TUBERS

Jimoh, M.O.[1*], Olukunle, O.J. [2], Ademosun, O.C.[2], and Manuwa, S.I.[2]

[1]Department of Food Science and Technology, Bells University of Technology, Ota, Nigeria.omotayojimoh50@yahoo.com. +2348053105074, +2347039394673

[2]Department of Agricultural Engineering, Federal University of Technology, Akure, Nigeria

ABSTRACT

The unit operations involved in cassava processing includes peeling, grating, boiling/parboiling, drying, milling, pressing, sieving, extrusion and frying. Before cassava tuber is processed into any of its food and non-food product, it must be peeled. Several processing of cassava had been mechanized successfully; however, cassava peeling remains a serious global challenge to design engineers and food processorsto date as much of it is still done manually. This research investigates effect of physical and mechanical properties of cassava tuber during mechanical peeling so as to mechanize peel removal. A machine for peeling cassava was developed. The design of the machine was based on the development and modification of the peeling tool of previous cassava peeling machines. Physical and mechanical properties such as tuber weight,w_1, proportion by weight of peel,w_p, tuber diameter, t_d, peel thickness, t_p, tuber surface taper angle, α, peel penetration force, F, and peel shearing stress,$t_s$were determined. Machine operational parameters such as peeling efficiency, P_E, mechanical damage, M_D, peel retention, P_R, quality performance efficiency, Q_{PE}, and throughput capacity, T_C were also determined.

The results showed that;w_1 ranges from 240-2300g,w_p ranges from 12.18-19.08%, t_d ranges from 32.66-138.00mm,t_p ranges from 1.60-4.34mm, α ranges from 9.05-24.10^0, F ranges from 0.16-1.83 N/mm, andt_s ranges from 0.80-9.15 N/mm^2.P_E ranges from 84.97-94.60%, M_D ranges from 1.57-11.19%, P_R ranges from 5.41-15.03%, Q_{PE} ranges from 77.97- 92.27% and T_C ranges from 387.10-1046.50 kg/h.Performance of the machineimproves as its speed increases up to 130 rpm and declined as the speed further increases,this is because the shearing stress is exceeded and more damage is done to the tuber flesh.

Keywords: mechanization, cassava, efficiency, peeling, properties

1. Introduction

Cassava (*Manihotesculenta*Crantz) is one of the most important food energy and staple crops in Tropical countries. Nigeria, Brazil, Thailand and Indonesia are the principal producing countries andthis is because of its suitability for present farming and food production (Olakulehin and Ajijola, 2005).Cassava is an established commercial crop and hundreds of its varieties are in existence, little is generally known of the nomenclature and identification of varieties. Various varieties are usually differentiated from one another by their morphological characteristic such as colour of stems, petioles, leaves and tubers. Moreover, in many instances, the same variety is known in various places by a number of names. The numerous varieties of cassava are usually grouped in two main categories: *Manihot palmate* and *Manihotutilissima*, or bitter and sweet cassava (Grace, 2004). This grouping is a matter of economic convenience, as it is difficult to distinguish the two groups by botanical characteristics. However, the distinction between them rest upon the content of hydrocyanic acid, which causes toxicity in the roots. This toxicity is not a

variety constant but varies from place to place. Hydrocyanic acid content tends to be higher in poor soils and in dry conditions. According to the recognized classification, sweet or nontoxic roots contain less than 50 milligrams of hydrocyanic acid per kilogram of fresh matter (Erhabor and Emokaro, 2007). At one time, it was thought that the toxicity of cassava root was associated with species or variety, but the hydrocyanic acid content was found to vary markedly with growing conditions, soil, moisture, temperature and age of the plant. Certain varieties in Africa, for instance were found to be innocuous in Dahomey and poisonous when grown in forest soils in Nigeria, the so called bitter type from Jamaica failed to produce the toxic substance when grown in Costa Rica.

Olukunle and Oguntude, (2007) reported that soil factors such as soil type, soil moisture, soil fertility, tillage practice and vegetation of the farm would also influence tuber shape and size which has constituted a major bottleneck in cassava peeling. Initial research efforts in peeling mechanization resulted in the production of several prototypes with relatively low peeling efficiencies and poor quality performance efficiency.This research aimed at investigating effect of physical and mechanical properties of cassava tuber and to achieve a good tool configuration so as to make 100% cassava tuber flesh recovery irrespective of the size, shape and orientation of the tuber.

2. MATERIALS AND METHODS

An improved commercially acceptable variety, TMS30572 (S_{Akure}) from teaching and research farm, Federal University of Technology, Akure was freshly harvested at age 15-18 months for the experiment. Compared to other varieties, it has low cyanogenic potential (CNp) with less than 5mg of hydrocyanic acid per 100g of tuber, it is more tolerant to low soil fertility, and more resistance to pest and diseases. More importantly too, it produces very well on soil so depleted by repeated cultivation. An automated cassava peeling machine designed and fabricated in the Department of Agricultural Engineering, Federal University of Technology, Akure was used during peeling process.

2.1. Measuring Toolsand Instruments

A variety of tools and instruments were used to carry out different measurements on the root tubers. A tap measure was used to measure the lengths of tubers while the diameters of the tubers were measured using a pair of vernier caliper. The weights of tubers before and after peeling and that of the peels were measured with an electronic weighing balance while the thickness of the tuber peel was measured by micrometer screw gauge.

2.2. Determination of Physical and Mechanical properties of Cassava tuber

2.2.1. Tuber Weight and Peel Weight (mm)

The tubers were graded into small, medium and large sizes. 20 tubers of each size range were considered during experiment. The graded tubers were weighed separately and the weight of each tuber, $w_{1,}$ average weight, $w_{aw,}$ and its standard deviation, Sdwere noted. Each of the tubers was then carefully hand-peeled such that no traces of tuber flesh were found on the peel. The weight of tuber flesh hand-peeled, w_2 was also noted. The proportion by weight of peel, w_p, average proportion by weight of peel, w_{ap}, and its standard deviation, Sd for each size range were also determined using expression:

$$w_p = \left[\frac{w_1 - w_2}{w_1} \right] \text{.....2.1}$$

2.2.2. Tuber Diameter and Peel Thickness (mm)

Another 60 tubers were collected and graded into small, medium and large sizes. A transverse division marks were made on the surface of each tuber at interval of 50mm from the proximal to the distal end. Each tuber was cut through along the mark and the diameter, $t_{d,}$ average diameter, $t_{ad,}$ and its standard deviation, Sd for each slice were determined along four different diametric lines approximately 45^0 to each other. The peel was carefully removed from the surface of each tuber slice and the thickness of the peel for respective slice was taken. For each of the size range, peel thickness, $t_{p,}$ average peel thickness, $t_{ap,}$ and its standard deviation Sd were determined.

2.2.3. Tuber Surface Taper Angle (^{o})

The shape of cassava slice at 50mm interval becomes frustum of a right circular cone. To determine the taper angle, α, the two slanting sides are projected further to meet at point O; angle subtended by the right circular cone at the point of interception is the tuber surface taper angle. Average taper angle, α_a, and its standard deviation, Sd, for each size range were also determined.

Peel Penetration Force (N/mm)

To determine peel penetration force per unit length of cutting blade, the sliced root to be peeled is considered as an approximate frustum of a cone. This is done so as to reduce the problem posed by tuber size and shape. The concept of this is to generate a force that will be sufficient to penetrate through the peel thickness during peeling process to achieve 100% useful tuber flesh recovery. Peel penetration force is calculated from the data obtained using the following expression:

$$F = K_s \left[\frac{t_{ap}}{w} \frac{F_p}{l_1} \right] \text{.....2.2}$$

Where F is the force require to penetrate through root peel, t_{ap} is the average tuber peel thickness, F_p is the force in play as a result of pressure exerted by the tuber on the cutting tool during peeling, w is the difference between peel thickness and height of the cutting blade, l_1 is the length of line of contact of the cutting blade on the tuber, k_s is the constant proportionality, k_s = 0.207 (Adetan*et al*., 2006). Average force of penetration, F_a, and its standard deviation, Sd, were determined.

2.2.4. Peel Shearing Stress (N/mm^2)

Tuber shearing stress is determined by dividing peel penetration force by 0.50mm, the thickness of the cutting blade on the cutting tool. The peel shearing stress, t_s, average peel shearing stress, t_{as}, and its standard deviation were also determined.

2.3. Effect of Crop and Machine Parameters on Machine Performance

The machine was evaluated using a gear driven variable speed motor at 100, 110, 120, 130 and 140 rpmwhile different feed rate, 10, 20, 30, 40, and 50kg for each of the machine speed were considered for the experiment. The tuber flesh is collected at tuber outlet while tuber peel is collected at peel outlet. The machine functional parameters such as peeling efficiency,

P_E(%),mechanical damage, M_D(%),peel retention, P_R(%), quality performance efficiency Q_{PE}(%) and throughput capacity, T_C (kg/h) were determined using the following expressions.

$$\textit{Peeling efficiency, } P_E = \left[\frac{w_{pr}}{w_{pr} + w_{prh}}\right] \quad \text{.....2.3}$$

$$\textit{Mechanical damage, } M_D = \left[\frac{w_{trp}}{w_{trp} + w_{tc}}\right] \quad \text{.....2.4}$$

$$\textit{Peel retention, } P_R = \left[\frac{w_{prh}}{w_{prh} + w_{pr}}\right] \quad \text{.....2.5}$$

$$\textit{Quality performance efficiency, } Q_{PE} = \left[(I - M_D)(1 - P_R)\right] \quad \text{.....2.6}$$

$$\text{Throughput capacity, } T_C = \left[\frac{w_{pr} + w_{prh} + w_{trp} + w_{tc}}{T}\right] \quad \text{.....2.7}$$

Where W_{pr} is weight of peel removed by machine, W_{prh} is weight of peel removed by hand after machine peeling, W_{trp} is weight of tuber flesh removed along with peel and W_{tc} is weight of tuber flesh completely peeled

3. RESULTS AND DISCUSSION

3.1. Results of Physical and Mechanical Properties of Cassava Tubers

The data obtained from physical and mechanical properties are summarized in Table 3.1- 3.7. Tuber weight (w_1) ranges from 240-2300g with average 298, 900 and 1806g for small, medium and large sizes respectively as shown in Table 3.1. Proportion by weight of peel (w_p) ranges from 12.18-19.08%with average 13.67, 14.72 and 16.50% for small, medium and large sizes respectively as shown in Table 3.2 which is similarto 10.6-21.5% reported by (Adetan*et at.*,2003). Tuber diameter (t_d) ranges from 32.66-138.00mm with average 50.13, 80.40 and 102.12mm for small, medium and large sizes respectively as shown in Table 3.3. Peel thickness (t_p) ranges from 1.60-4.34mm with average 2.58, 2.67 and 3.27mm for small, medium and large sizes respectively as shown in Table 3.4. Surface taper angle (α) ranges from 9.05-24.10^0 with average 10.71, 12.14 and 16 58^0 for small, medium and large sizes respectively as shown in Table 3.5. Peel penetration force per unit length of cutting blade (F) ranges from 0.16-1.83N/mm with average 0.88, 1.03 and 1.20N/mm for small, medium and large sizes respectively as shown in Table 3.6. Peel shearing stress (t_s) ranges from 0.80-9.15 N/mm^2 with average 4.40, 5.15 and 6.00

N/mm^2 for small, medium and large sizes respectively as shown in Table 3.7 which is in accordance with 0.68-9.60 N/mm^2 reported by (Odigboh, 1983).

3.2. Results of the Machine Performance

The performance evaluation of the machine revealed that as speed of the machine increased from 100-130 rpm;at 10kg, P_E increased from 84.97-94.60% and decreased to 93.18% as speed further increased to 140 rpm, at 20kg, it increased from 86.96-94.37% and decreased to 92.88% as speed increased to 140 rpm, at 30kg it increased from 86.06-93.95% and decreased to 92.42% at 140 rpm, at 40kg, it increased from 86.80-93.22% and decreased to 91.92% as speed moved to 140 rpm, at 50kg, it also increased from 87.19-92.68% and decreased to 91.71% as speed further increased to 140 rpm as shown in Figure 3.1. As speed of the machine increased from 100-140 rpm; at 10kg, M_D increased from 1.57-3.03%, at 20kg, it increased from 2.36-4.25%, at 30kg, it increased from 3.89-4.61%, at 40kg, it also increased from 8.06-8.71% and at 50kg, it increased from 10.57-11.19% as shown in Figure 3.2. As the speed of the machine increased from 100-130 rpm; at 10kg, P_R decreased from 15.03-5.41% and later increased to 6.82% as speed further increased to 140 rpm, at 20kg, it decreased from 13.04-5.63% and increased to 7.12 as speed increased to 140 rpm, at 30 kg, P_R decreased from 13.94-6.05% and increased to 7.58% as speed moved to 140 rpm, at 40kg, it decreased from 13.20-6.78% and increased to 8.09% at speed 140 rpm, and at 50kg, it also decreased from 12.82-7.32% and increased to 8.29% as speed further increased to 140 rpm as shown in Figure 3.3. As the speed of the machine increased from 100-130 rpm; at 10kg, Q_{PE} increased from 83.64-92.27% and later decreased to 90.36% as speed further increased to 140 rpm, at 20kg, it increased from 84.91-91.50% and decreased to 88.93% at 140 rpm, at 30kg, it increased from 82.71-89.77% and decreased to 88.16% as speed increased to 140 rpm, at 40kg, Q_{PE} increased from 79.80-85.23% and decreased to 83.91% as speed increased to 140 rpm, at 50kg, it also increased from 77.97-82.44% and later decreased to 81.45% as speed of the machine increased to 140 rpm as shown in Figure 3.4. The reason why there is decline in the performance of the machine at speed 140 rpm, the shearing stress is exceeded at this speed and more damage is done to tuber flesh. As speed of the machine increased from 100-140 rpm; T_C increased from 387.10-423.53 kg/h at 10kg, it also increased from 685.71- 757.89 kg/h at 20kg, it increased from 857.14-947.37 kg/h at 30kg, it increased from 947.37-1043.50 kg/h at 40kg, and increased from 972.97-1046.50 kg/h at 50kg as shown in Figure 3.5.

4. CONCLUSION

1. Cutting of tubers into slices to form frustum of a cone addresses the problem posed by tuber size and shape so as to enhance effective quality peeling. This information is very important in designing a peeling machine that would slice cassava tuber, sort the slices into diameter group and peel in different sections of the machine's unit.
2. Performance of the machineshows 100% tuber flesh recovery because broken tubers could either be processed along with whole tuber or adopted for animal feeds.
3. The wider clearance between cutting tool and the opening of peeling chamber allows tubers with smaller diameter to escape along with tuber peel. Therefore smaller clearance between cutting tool and peeling chamber is recommended for further study.

REFERENCES

Adetan, D.A., Adekoya L.O., and Aluko O.B., 2003.Characterisation of some properties of cassava root tubers. *Journal of Food Engineering*, 59,349-353.

Adetan, D.A., Adekoya L.O., and Aluko O.B., 2006.Theory of mechanical method of peeling cassava tubers with knives.*International Journal of Agrophysics,* 20, 269-276.

Erhabor, P.O. and Emokaro, C.O. (2007).Econimic importance of cassava.In: Erhabor, P.O.,

Azaiki, S.S. and Ingawa, S.A. (eds.) *Cassava the White Gold*.Initiative Publication Co. Benin. Pp 1-16

Grace, M.R. 2004.FAO Plant Production and Production Series No. 3.

Odigboh, E.U. 1983. Cassava production, processing and utilization. In. H.T. Chan (Ed.), *Handbook of Tropical Foods*. Mercel Decker Pub.Inc., 270, Madison Avenue, New York.Pp 145-200.

Olakulehin, J.O., and Ajijola, F.S., (2005). Cassava production: Nigerians best kept secretLagos farmers 1,Pp 1-4.

Olukunle O.J. and Oguntunde, P.G, 2007.Analysis of peeling pattern in an automated cassavapeeling machine.*Nigerian Journal of Technological Development*, 6 (1&2) 41-52, Facultyof Engineering, University of Ilorin, Ilorin, Nigeria.

Table 3.1: Tuber weight

Size	Tuber weight TMS30572 (S_{Akure})		
	Range (g)	w_{aw}	Sd
Small	$240<w_1<818$	298	7
Medium	$782<w_1<1700$	900	13
Large	$1655<w_1<2300$	1806	18

Table 3.2: Proportion by weight of peel

Size	Proportion by weight TMS30572 (S_{Akure})		
	Range (%)	w_{ap} (%)	Sd
Small	$12.18<w_p<15.61$	13.67	0.14
Medium	$13.10<w_p<16.40$	14.72	0.15
Large	$13.84<w_p<19.08$	16.50	0.20

Table 3.3: Tuber diameter

Size	Tuber diameter TMS30572 (S_{Akure})		
	Range(mm)	t_{ad}(mm)	Sd
Small	$32.66<t_d<70.58$	50.13	11.47
Medium	$51.48<t_d<102.23$	80.40	12.61
Large	$74.72<t_d<138.00$	102.12	15.94

Table 3.4: Tuber peel thickness

Size	Peel thickness TMS30572 (S_{Akure})		
	Range(mm)	t_{ap}(mm)	Sd
Small	$1.60<t_p<4.23$	2.58	0.76
Medium	$1.81<t_p<4.26$	2.67	0.56
Large	$1.86<t_p<4.34$	3.27	0.35

Table 3.5: Tuber surface taper angle

Size	Surface taper angle TMS30572 (S_{Akure})		
	Range (^{0})	α_a (^{0})	Sd
Small	$9.05<\alpha<14.55$	10.71	0.40
Medium	$10.60<\alpha<20.18$	12.14	0.64
Large	$15.38<\alpha<24.10$	16.58	0.97

Table 3.6: Peel penetration force

Size	Peel penetration force TMS30572 (S_{Akure})		
	Range (N/mm)	F_a (N/mm)	Sd
Small	$0.16<F<1.11$	0.88	0.08

Medium	0.22<F<1.34	1.03	0.15
Large	0.57<F<1.83	1.20	0.23

Table 3.7: Peel shearing stress

Size	Peel shearing stress TMS30572 (S_{Akure})		
	Range (N/mm^2)	t_{as}(N/mm^2)	Sd
Small	$0.80<t_s<5.55$	4.40	0.40
Medium	$1.10<t_s<6.70$	5.15	0.75
Large	$2.85<t_s<9.15$	6.00	1.15

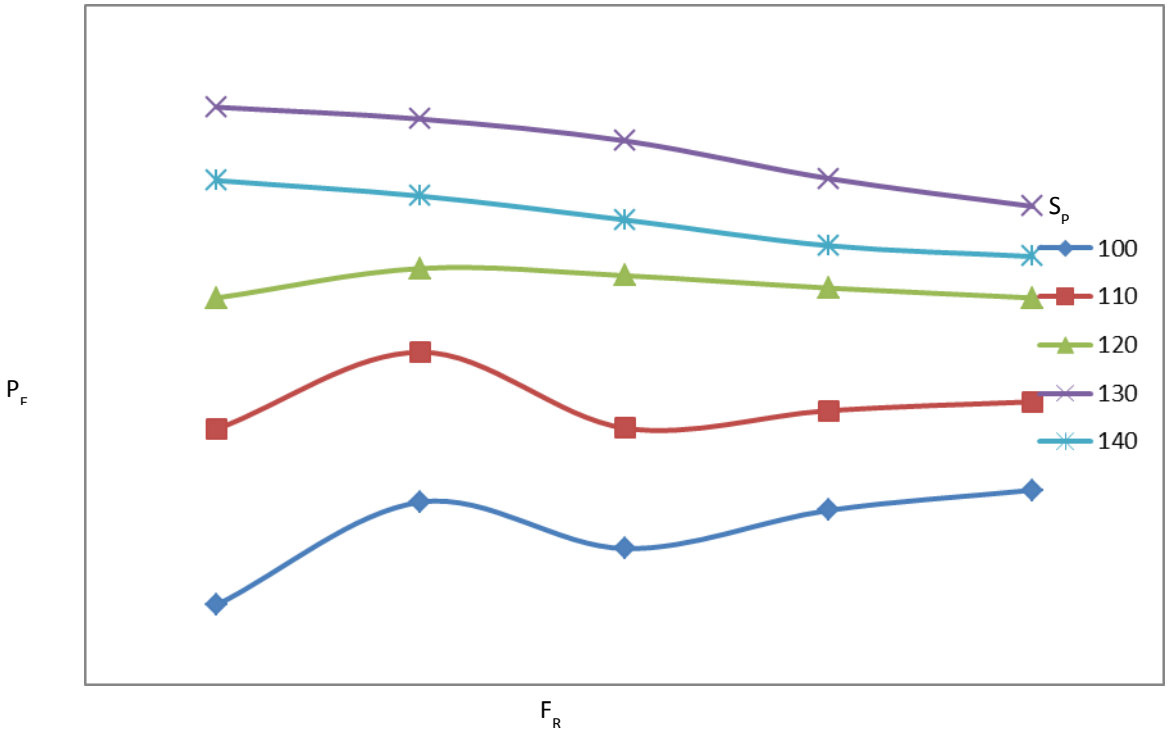


Figure 3.1: Graph of P_E on feed rate at different machine speed for TMS30572 (S_{Akure})

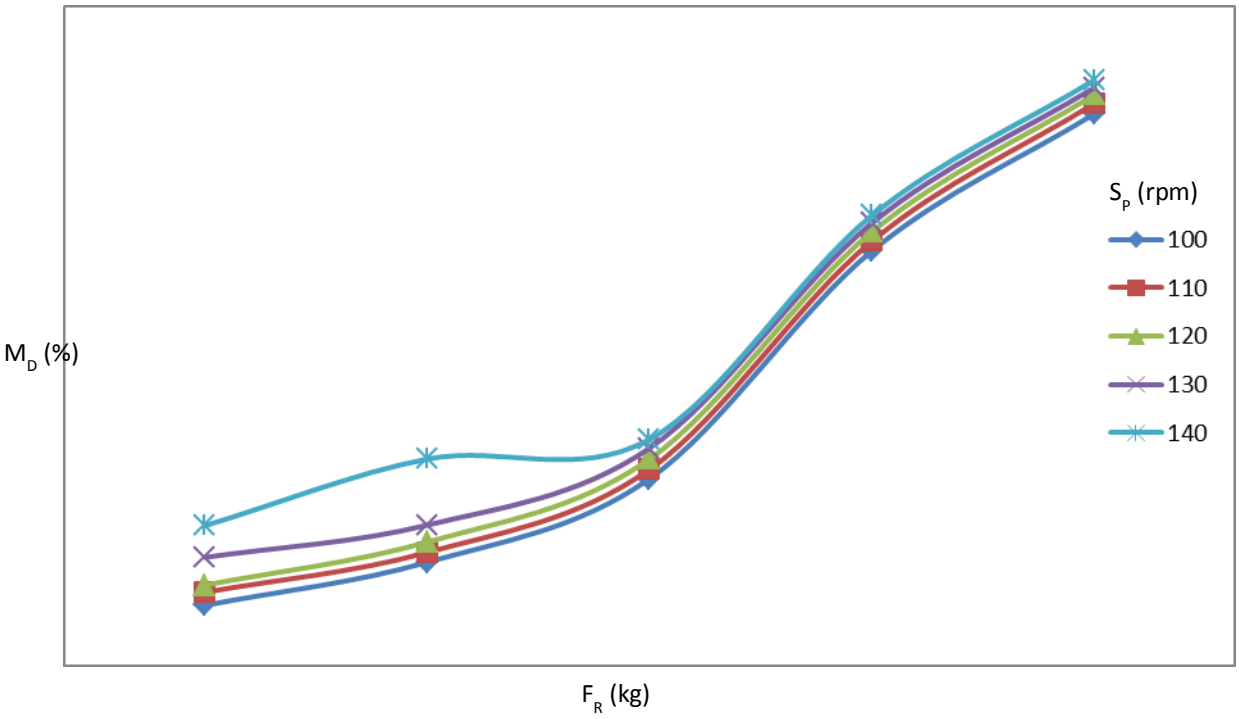


Figure 3.2: Graph of M_D on feed rate at different machine speed for TMS30572 (S_{Akure})

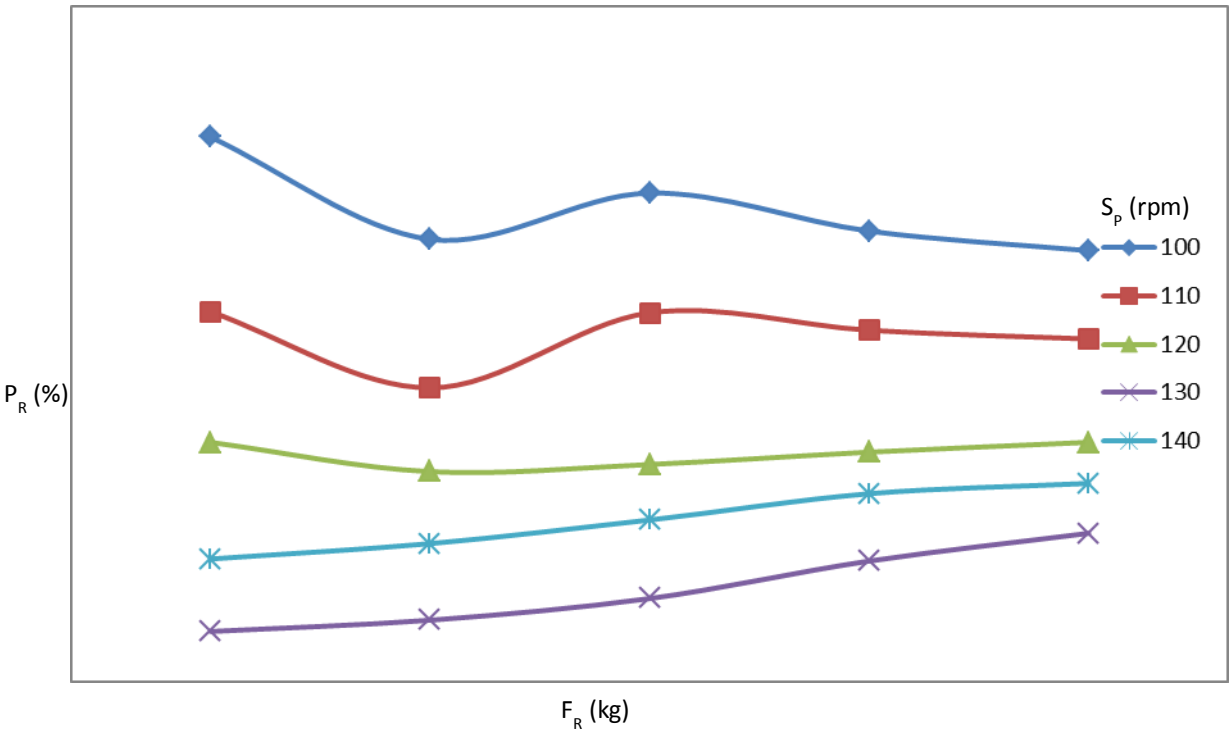


Figure 3.3: Graph of P_R on feed rate at different machine speed for TMS30572 (S_{Akure})

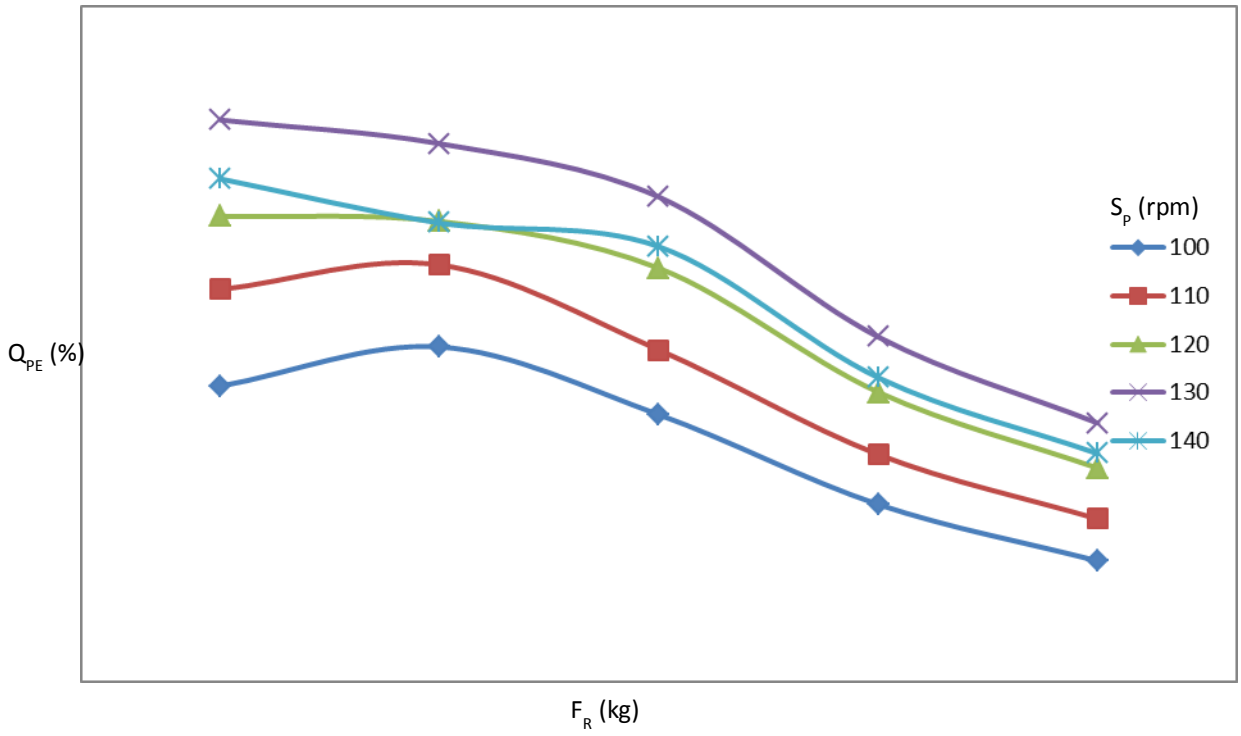


Figure 3.4: Graph of Q_{PE} on feed rate at different machine speed for TMS30572 (S_{Akure})

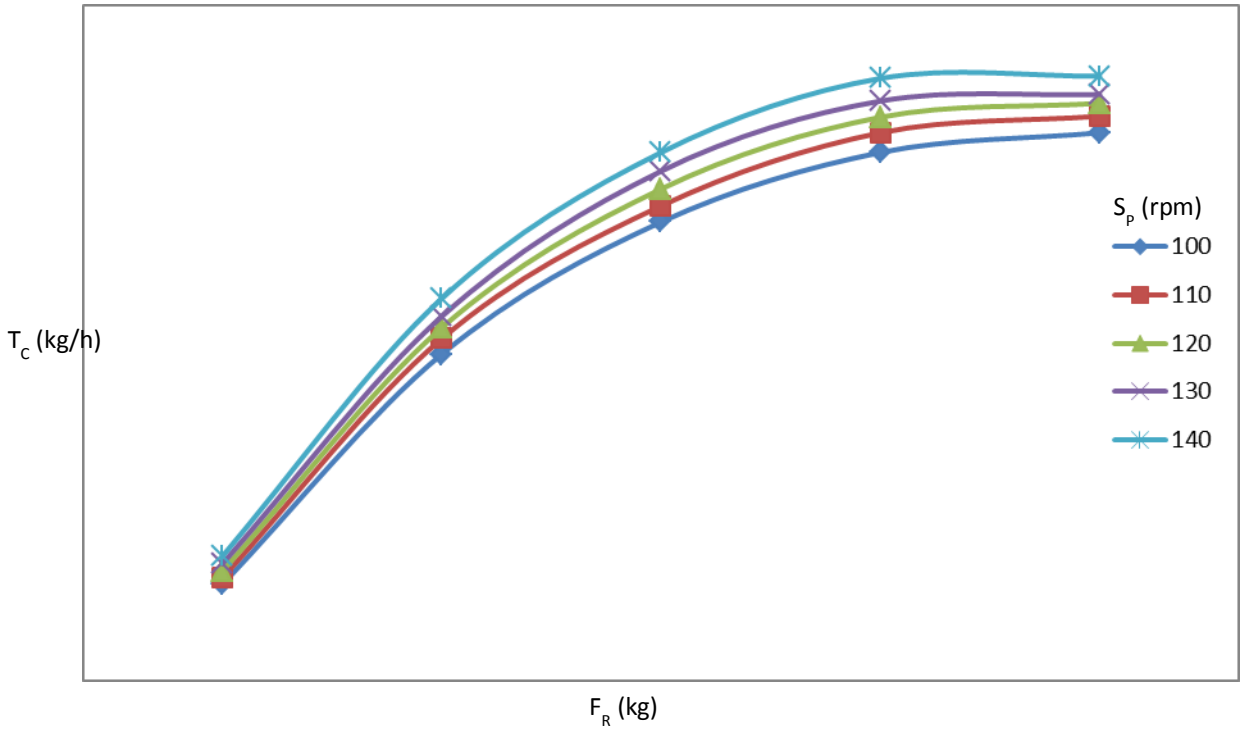


Figure 3.5: Graph of T_C on feed rate at different machine speed for TMS30572 (S_{Akure})

DEVELOPMENT AND PERFORMANCE EVALUATION OF THE CLEANING SYSTEM OF THE SWARAJ THRESHER

Ali M. A., Usman, A.G., and Lawan, I.

Department of Agricultural Engineering,Faculty of Engineering,Bayero University, Kano.binlawan@yahoo.com. +2348069150069.

ABSTRACT

A study undertaken by Ibrahim (2008) to identify types of sorghum threshers available in Kano State and the type most suitable for sorghum threshing revealed that Swaraj thresher was the most suitable from performance and operational point of view. It has threshing output of 274.01 kg/hr and threshing efficiency of 99.81%. The only glaring limitation was the low level of cleaning efficiency (73.68%), resulting in low acceptance by farmers, who instead continue with manual threshing. To improve on the cleaning performance and enhance the adoption of mechanical threshing, an improvement of the cleaning system was carried out, resulting in better level of cleaning (94.92%). Also performance evaluation of the thresher, with the improved cleaner, at three different speeds (i.e. 800rpm, 870rpm and 900rpm) and three feed rates (i.e. 6kg/min, 7.5kg/min and 10kg/min) gave results that compare favorably with performances of other threshers(i.e. IAR thresher).

Keywords: Thresher, Sorghum, Screen, Sieve, Efficiency.

1.0 Introduction

Kano state is the most populous state in Nigeria with a population of 9,401,288, by 2006 census figures. Agriculture is the major economic activity of the state and offers employment to more than 90% of the people. Major crops grown in Kano include wheat, rice, groundnut, cotton, millet and sorghum.Kano is one of themajor sources of sorghum produced in Nigeria, which is estimated at 200,000 tons per annum, ranking Nigeria as second largest producer of sorghum in the world (USAID, 2006).

Despite the high production in the state, studies by Mustapha (2008) revealed that threshing of sorghum is still by manual method which includes: beating the head strenuously with sticks at different spots in or near the farm or using pestle and mortar or by putting the sorghum head inside bag and beating with sticks. All these processes result in drudgery and losses. This information is in line with findings of Simonyan and Imokheme (2006) who reported that the traditional method of sorghum threshing in Nigeria is manual involving beating the head strenuously with sticks. Oja and Micheal (2003) also pointed out that indigenous threshing of sorghum is one of the time consuming, laborious and uneconomical activities. Also, Ali (1986) classified manual threshing of sorghum as heavy workload in terms of energy expenditure of 41.87kJ/min and heartbeat of 150 beats/min. Apart from the large labor requirement, this is a very hard task; in addition, the operation did not encourage high production and often results in a low quality(FAO,2007).

The prevailing practice of manual threshing, therefore calls for change and action considering the large production of sorghum in the state and the economic importance of the crop globally.This

prompted Mustapha (2008) to make further enquiries which revealed that threshers were available in Ministry of Agriculture and Natural Resources, Kano State, and Kano State Agricultural and Rural Development Authority (KNARDA), but werenot sought by the farmers for varied reasons, including unsatisfactory performances of the machines. Amongst the threshers available in the state, Ibrahim (2008) found that Swaraj thresher was the most suitable thresher for sorghum threshing from performance and operational point of view, but had low level of cleaning efficiency (73.68%),resulting in low acceptance by the Kano State farmers.

In order to upgrade the performance of this thresher and enhance adoption by Kano State farmers, improvement of the cleaning system of the Swaraj thresher was carried out.

2.0 MATERIALS AND METHODS

The entire study was limited to improving the cleaning efficiency of the Swaraj sorghum thresher available in Department of Agricultural Engineering, Ministry of Agriculture and Natural Resources Kano State. The methodology adopted in modification, testing of the Swaraj sorghum thresher was as follows:

- Measurement of physical properties of sorghum
- Design and construction of the cleaning system based on the physical properties of the sorghum obtained.
- Comparative performance evaluation of the thresher with the old and the new cleaner.
- Detailed Performance evaluation of the Swaraj with the new cleaner.

Detailed methodology used in achieving each of the above mentioned steps are as follows:

2.1 Determination of Physical Properties

To design a suitable screen for sorghum cleaning, the physical properties of sorghum were evaluated. The physical properties included the thickness and length. The thickness was measured using a micrometer screw gauge while the length was evaluated with a verniercaliper. Three common varieties of sorghum grown in Kano (i.e. Samsorg-7, Samsorg-41 and Samsorg-38) were used as samples. Twenty samples of each variety of sorghum were used for each test. On each sample,the thickness and the length were obtained and recorded.

2.2 Design of the Screen/Sieve

The design of the screen holes was done based on the physical properties obtained in 2.1 above. The major design considerations included:

(i)To design a sieve so as to fit in the existing thresher (i.e. should not be bigger than the existing sieve).

(ii) To determine diameter of the sieve holes based on the results obtained in 2.1 above.

(iii) To select and use material of sufficient strength to withstand the repetitive impact of the concave beaters on the sieve.

(iv) To use material that is cost effective.

2.2.1 To Design a Sieve So as to Fit in the Existing Thresher

To ensure the new sieve fits into the space initially provided for the screen, dimensions of the previous screen were measured and adopted. Thus, the selected steel plate was cut to 75cm length by 17cm breadth in order to fit into available space for screen on the Swaraj thresher.

2.2.2 To Determine Diameter of the Sieve Holes

The diameter of the hole should be such that all sorghum grains should pass through after they are detached from the sorghum ears. From results obtained by measurement of sorghum samples, the maximum value of thickness obtained was 3.59mm, and the maximum length was 4.95mm. Thus to accommodate the grains irrespective of their orientation when they land on the screen, a diameter of 5mm was chosen.

2.2.3 Selection of Material

The sieve was constructed using a mild steel plate made of 3mm metal thickness, which is of sufficient strength to withstand the repetitive impacts of the threshing process.

2.3 Construction of the Sieve/Screen

The curvature of the sieve was determined by considering the clearance and the distance of the tip of the peg to the drum shaft centre. The mild steel plate was cut to 75cm length by 17cm breadth in order to fit into available space for screen on the Swaraj thresher. Holes of 5mm diameter were drilled on the screen using a 5mm drill bit. Also the hole were constructed with centre to centre of 5.5mm and distance to distance of 2mm.The sieve was rolled using the rolling machine to give a curved surface, as shown in Plate 1.0

2.4 Performance Evaluation

The evaluation test was carried out at Ministry of Agriculture and Natural Resources Farm Centre, Kano State. Two types of evaluation were conducted viz:

2.4.1 Comparative Evaluation

The thresher (Plate 2.0) was evaluated using both the old and the new cleaning systems to determine the level of improvement achieved. The comparative tests was carried out using speed of 870rpm and feedrates of6, 7.5 and 10 kg/min. Performance parameter evaluated was only the cleaning efficiency.

2.4.2 Evaluation underDifferent Operating parameters

The thresher was evaluated so as to compare its performance with other threshers commonly used elsewhere. The performance evaluation of the Swaraj Sorghum thresher, using different levels of operating parameters, was carried out using a procedure as reported by Dangora et al (2006). Operating parameters used for the tests were:

i. Speed: 800rpm, 870rpm and 900rpm.
ii. Feedrate: 6 kg, 7.5kg and 10 kg

The commonest variety in Kano state, Samsorg-7, was used for the evaluation.

Performance parameters used for the evaluation were thresher output (kg/hr), cleaning efficiency (%) and threshing efficiency (%).

To obtain the thresher output (kg/hr) at a feed rate of 6kg/min, 7.5kg/min and 10kg/min, the quantity of threshed sorghum was collected at the grain outlet and measured and the corresponding time from the feeding to the collection at the outlet was also recorded. Then the thresher output was obtained using the following relationship:

$$Q = q/t \text{---------- (1)}$$

Where,
Q = thresher output (kg/hr),
q = weight of threshed sorghum (kg),
t = Time of threshed sorghum (hr).

The cleaning efficiency of the thresher was obtained by using weight of clean grain (obtained after further manual cleaning of machine effluents) and the total material collected (with some chaffs) at the grain outlet per unit time, using the relationship below:

$$CE = (B/D) \times 100 \text{---------- (2)}$$

Where,
CE = Cleaning Efficiency (%)

B = Weight of clean grain (kg)

D= Weight of total grain collected with some chaffs at the outlet (kg)

Threshing efficiency was obtained by weighing the quantity of un-threshed sorghum per unit time and the total weight of sorghum input which were then substituted in the relationship.

$$ET = 100 - (A/I)$$

Where: ET = Threshing efficiency

A = Height of unthreshed sorghum per unit time (Kg)

I = Total weight of sorghum input (kg).(Dangora*et al*, 2006).

3.0 RESULTS AND DISCUSSIONS

3.1 Physical Properties of Sorghum

Results of the physical measurement of grain samples of the common varieties of sorghum revealed that the maximum value of thickness obtained was 3.59mm, and the maximum length was 4.95mm. Thus to accommodate the grains irrespective of their orientation when they drop on the screen, a diameter of 5mm was chosen.

3.2 Design and Construction of an Improved Sieve

An improved sieve was designed based on physical properties of the sorghum grain. Design parameters used in construction of the sieve are tabulated in Table 1 below.

3.3 Performance Evaluation

3.3.1 Comparative Performance of the two Cleaning Systems

Results obtained from the comparative evaluation are presented in Table 2. The results indicate that there was marked improvement (21.73% - 30.62%) of the cleaning performance under same operating parameters, as detailed in 2.4.1.The present cleaning performance, 94.9%, compares fairly with manual cleaning presently used by the farmers.

3.3.2 Performance Evaluation under different Operating parameters

Results of the performance evaluation under different operating parameters, as detailed in 2.4.2, are presented in Tables 3 to 5 below. The results indicate the following:

i. At each feed rate, there is a speed that gives the best cleaning performance. For 6kg/min, the optimum speed is 800rpmwith91.85% cleaning efficiency; for 7.5kg/min, the speed is 870rpm with 94.92%; and for 10kg/min the speed is 800rpm and the corresponding cleaning efficiency is 90.54%. This shows that for any feedrate, there is a speed that synchronizes best to give an optimal performance. These results are of operational significance.
ii. The highest cleaning efficiency was obtained with 7.5kg/min and 870rpm. This represents the optimum operating condition (threshing output 274.91kg/hr, threshing efficiency of 97%, cleaning efficiency of 94.92%). This result compares favorably with performance of popular and accepted threshers like the I.A.R. thresher which has threshing capacity of 100kg/hr, threshing efficiency of 97%, cleaning efficiency of 92% and grain damage of less than 1.0% (I.A.R, 1987)
iii. The threshing efficiency was almost same for the various operating parameters, varying only from 99.78% to 99.91%.

4.0 CONCLUSION

The improvement work on the cleaning system of the Swaraj thresher has resulted in tremendous improvement of the cleaning efficiency of the thresher and of the overall performance of the thresher. Hopefully this outcome would enhance acceptability of the machine by the farmers, and change the current trend of manual threshing.

REFERENCES

Ali, M. A. 1986 Comparative Ergonomics Studies of Male and Female Operations on Selected Farm Task. Unpublished M.sc. Thesis. Ahmadu Bello University, Zaria Nigeria.

Dangora, N.D. Sulaiman, M.L. and Yusuf D.D. (2006): Modification of IAR Maize Dehusker Sheller for Sorghum Threshing "Proceeding of theSeventh InternationalConference of Institute For Agricultural Engineers" Vol. 28:pp; 106-109.

FAO 2007.Agricultural Engineering in Development Post-Harvest Operations.(Threshing and Shelling). http://www.fao.org/docep/19/1/07

Institute for Agricultural Research (1987); A Report on Agricultural Engineering Prototypes Agricultural Mechanization Research Programme. Ahmadu Bello University, Zaria.

Ibrahim L. (2008), A Survey of Available Rice and Sorghum Threshers in Kano State. Unpublished B.Eng thesis Department of Agric Engineering B.UK. Mustapha M. Bello (2008):

Rice And Sorghum Threshing: A Study TowardsUpgrading the Current Practice in Kano State. Unpublished B. Eng. Thesis, Department of Agric. Engineering, Bayero University, Kano.
Ojha D.A and Micheal A. (2003); Performance Evaluation of Foot Operated Thresher. AMA Journal Vol. 33. No 3. Pp 140-141
Simonyan, K. J. and Imokheme, P. A. 2006.Development of an Arial MotorizedSorghum Thresher. Proceedings of the Seventh International Conference of the Nigerian Institution of Agricultural Engineers, 28:376-380.
USAID 2006.Trip Report: Northern Nigeria Joint Food Supply Assessment Mission.http://www.fews.net/nigeria..pdf



Plate 1.0: Improved Screen/Sieve



Plate 2.0: Experimental Set-up

Table 1: Design Parameters of the Improved Sieve

S/No	Parameter	Specification
1	Length	75cm
2	Breadth	17cm
3	Material	Mild steel plate, 3mm thickness
4	Size of hole	5mm

Table 2.0: Comparative Cleaning Performance of the Swaraj Thresher Before and After Improvement of the Cleaning System

S/No.	Feedrate (kg/min)	Average CleaningEfficiency		Percentage Difference
		Before Improvement	After Improvement	
1	6	73.68	89.69	21.73
2	7.5	72.67	94.92	30.62
3	10	70.24	90.10	28.27

Table 3.0:Cleaning Efficiency at constant Feedrate (6kg/min) and Various Speeds

S/No	Speed (rpm)	Replication	Threshing output (kg/hr)	Cleaning efficiency (%)	Threshing Efficiency (%)
1	800	1	255.50	90.91	99.78
2		2	254.76	91.30	99.80
3		3	274.39	93.33	99.81
		Mean	261.55	91.85	99.80
4	870	1	257.14	88.89	99.82
5		2	257.14	88.89	99.84
6		3	314.61	91.30	99.82
		Mean	276.29	89.69	99.83
7	900	1	238.24	88.89	99.84
8		2	260.40	91.48	99.84
9		3	382.50	90.91	99.91
		Mean	293.71	90.43	99.86

Table 4.0: Cleaning Efficiency at Constant Feedrate (7.5kg/min) and Various Speeds

S/No	Speed (rpm)	Replication	Threshing output (kg/hr)	Cleaning efficiency (%)	Threshing Efficiency (%)
1	800	1	275.00	90.91	99.83
2		2	296.50	91.07	99.83
3		3	291.14	91.07	99.84
		Mean	287.54	91.02	99.83
4	870	1	234.76	93.33	99.84
5		2	282.16	94.83	99.84
6		3	307.83	96.61	99.82
		Mean	274.91	94.92	99.83
7	900	1	209.03	92.59	99.84
8		2	275.00	90.91	99.84
9		3	360.00	92.59	99.91
		Mean	281.34	92.03	99.86

Table 5.0: Cleaning Efficiency at Constant Feedrate (10kg/min) and Various Speeds

S/No	Speed (rpm)	Replication	Threshing output (kg/hr)	Cleaning efficiency (%)	Threshing Efficiency (%)
1	800	1	321.70	88.09	99.80
2		2	392.31	94.12	99.79
3		3	255.81	89.41	99.81
		Mean	323.27	90.54	99.80
4	870	1	364.28	88.24	99.82
5		2	398.41	93.97	99.81
6		3	277.71	88.09	99.79
		Mean	346.80	90.10	99.81
7	900	1	340.43	88.51	99.83
8		2	397.40	92.94	99.83
9		3	381.95	89.65	99.90
		Mean		90.37	99.85

ESTIMATED EQUATIONS FOR TIME, WATER AND ENERGY REQUIMENTS IN COOKING RICE

R* Akinoso, Aremu A.K. and T. T. Oyegunle
Department of Food Technology, University of Ibadan, Ibadan Nigeria.
akinoso2002@yahoo.com

ABSTRACT

Rice is an important household food. A study was conducted to develop equations for estimating the time, water and energy requirements in cooking rice. A 3 x 2 x 2 factorial experimental design was employed. Rice variety (o*fada, bida* and Royal), cooking method (open, closed) and quantity (173, 692 g) were variables. The responses were time, water and energy requirements. Results obtained varied between (40- 75 minutes) for time requirement, 329.3 – 1933.4 g water and 2.4 – 4.3 MJ for energy requirement. Linear regression models were found to be the most suitable for estimating time, water and energy requirements with Coefficients of determination R^2 of the equations ranging from 0.718 – 0.948. Analysis of variance of the data showed significant effects of treatment on the responses at 5% level of significance. Therefore, variety of rice, cooking method and quantity determine the time, energy and water requirements in rice cooking.

Key words: Rice cooking, time, water, energy, model

1.0.INTRODUCTION

Rice is an important cereal for human consumption grown in all the ecological and dietary zones of Nigeria (Sanni et al., 2005)**.** The two commonly cultivated varieties of rice in Nigeria are *Oryza sativa and Oryzaglabberima* (Abulude, 2004). The processing of rice involves the following unit operations, harvesting, threshing, cleaning, drying, parboiling, dehulling, de-braning, polishing, grading, packaging and cooking. Rice has potential in a wide range of food categories. Besides having nutritional and medicinal benefits, the by-products of rice are equally important and beneficial. By-products from growing rice create many valuable and worthwhile products. On the average, however a sample of milled rice grown will contain about 80% starch, 8% protein, 0.5% ash and 11% water.

Cooking requires the transformation of the potential energy in fuel into heat energy. There are many factors influencing the efficiency of cooking like the phenomenon of heat production, heat utilization, heat transmission and heat rejection during combustion. Rice is cooked by boiling or steaming. It can be cooked in just enough water (the absorption method), or it can be cooked in a large quantity of water which is drained before serving (the rapid-boil method). Rice may also be made into rice porridge by adding excess water so that the cooked rice is saturated with water to the point that it becomes very soft, expanded, and fluffy. Rice may be soaked prior to cooking. Rice is washed and boiled with water using different cooking devices which depends on energy.

Energy is an indispensable commodity for the economic growth and development of any nation. Energy is also an essential input to the growth and development of the various sectors of the economy. Energy is inevitable for poverty alleviation and provides services in the areas of health, communication and productivity. Knowledge of energy consumption in food processing is useful for several purposes such as budgeting, evaluation of energy consumption for a given product, forecasting energy requirement in a plant, and for planning plant expansion. Studies reported in literature on estimation of energy input in food processing include Mrini, Senhaji and Pimentel,

(2002) quantified energy requirements for sugar-beet production in Morocco; Jekayinfa and Bamgboye (2006) estimated energy requirements in cashew nut processing operations; Jekayinfa and Bamgboye (2007) developed equations for estimating energy requirements in palm-kernel oil processing operations; Le-bail et al., (2010) estimated energy demand for selected bread making processes; Abubakar, Umar and Ahmad (2010) energy utilization patterns in a sugar production factory in Nigeria and Atul et al., (2010) elucidation of unit and operations energy consumption pattern in small scale cashew nut processing mills.

Nigeria is endowed with a wide range of renewable and non – renewable energy sources. The non – renewable resources include crude oil, natural gas, coal, lignite, tar and nuclear fuels. The renewable ones include solar and wind energy. Nigeria operates a centralized energy system where communities and individuals are connected to a common energy source and because of the cost implication of connection to this source; many poor communities live without electricity. There is energy crisis in Nigeria; the cost of producing fossil fuels which is predominantly the source of energy used in cooking is expensive and electric power is unreliable. Therefore, the objective of the study was to generate mathematical equations for estimating time, water and energy requirements for cooking rice, a widely consumed cereal in Nigeria. The models will aid energy conservation studies.

2.0.MATERIALS AND METHODS

2.1 Experimental design

A 3 x 2 x 2 factorial experimental design was employed, that is three varieties of rice (*ofada, bida*,royal Stabilion), two cooking methods (open, close) and two different quantities (173 g, 692 g). The variables were coded as variety, ofada (-1), bida (1), royal (0); methods open (-1), close (1) and quantity, 173 (-1), 692 (1). Responses were water consumption, time and energy requirement (Table 1).

2.2 Preparation of Materials

Bida (an indigenous variety) and Royal Stabilion (Thailand) were procured from Bodija market, a local market in Ibadan, Oyo State Nigeria. While *ofada* (an indigenous variety) was sourced from Abeokuta, Ogun state Nigeria. The extraneous matters such as stone and dirt inside *ofada* and *bida* rice were blown-off and removed by hand picking before the required quantities were weighed. The Digital weighing balance (model:Gx/GF-1 3003858,A&D company Limited) used was first set to zero before 173±3g (approximately 1tin cup) of o*fada* rice, *bida* rice, royal Stabilion rice was weighed separately. This was also repeated for another quantity 692±5g (approximately 4 tin cups).

2.3 Cooking methods

The three rice varieties of *ofada, bida* and royal Stabilion rice were washed and cooked separately inside open and closed aluminum cooking pots (3mm thickness) using 1kW temperature regulated electric cooking plate (Crown star, Model MCHP-225, Rajko Traders Ltd, Hong Kong, China). The electric cooker was put on and left for 10 minutes to initialize before it was loaded.

2.4 Determination of cooking time

A trial experiment was first carried out to get approximate cooking time. After which, samples of the boiling rice were examined at 5 minutes interval by an experience analysis using objective

approach. At close of cooking time assessment period was reduced to 3 minutes interval. This was continued until it was pronounced satisfactory.

2.5 Determination of water requirement

The cooked rice was drained to remove excess water using sieve. This was left to stand for about 30 minute to equilibrate with ambient temperature 29±2℃. The difference between the weight of raw rice and cooked rice was recorded as quantity of water consumed.

2.6 Determination of energy requirement

Energy utilization was quantified as a function of electrical power and time (Equation 1)

$$En = powerxtime \qquad 1$$

2.7 Statistical Analysis

All the experimental procedures were repeated three times. Mean values were recorded as obtained data. These were subjected to analysis of variance (ANOVA) at 5% level of significance. Regression equations were developed using propriety software package SPSS 14.0 for windows. The models were subjected to coefficient of determination and lack of fit test at 5% level of significance.

3.0. RESULTS AND DISCUSSION

3.1 Time requirement

Recorded duration for cooking the variety and quantity of rice under consideration varied between 40 and 75 minutes. Effects of treatments were found to be significant on time requirement ($p< 0.05$). Using linear regression (Equation 2) to express the relationship gave high coefficient of determination (0.974), an indication of good fitness. Variety and quantity of rice were the significant model terms (Table 2). Khatoon (2006) reported similar observation. Graphical illustration of the relationship is presented as Fig. 1.

$$T = 57.42 - 3.25V - 2.08M + 11.75Q \qquad 2$$

3.2 Water requirement

Highest quantity of water required to cook was 1933.4 g. This was recorded when 692 g of royal rice was cooked in a close pan. While the least water requirement of 329.2 g was obtained when 173 g of *ofada* rice was cooked in open pan. Level of water absorption is an indicative test for rice cooking. This result suggests that royal rice has highest water absorption capacity, and cooking rate. This agreed with Osaretin and Abosede (2007) report on comparison of *ofada* and polished rice cooking rate. Analysis of variance of the data showed significant effect of treatments on water absorption capacity at 5 % level of significance. Mathematical expression of the relationship is presented as Equation 3. Coefficient of determinationR^2 of the model is 0.718. Test of significance of the model coefficients revealed quantity that quantity of cooked rice as the only independent significant model term (Table 3). This is suggesting that quantity as the major factor determining water requirement in rice cooking. Response surface plot of effects of the treatments on water requirement is shown in Figure 2.

$$W = 972.50 - 219.84V - 2.90M + 515.97Q \qquad 3$$

3.3 Energy requirements

Maximum and least energy expended were 4.3 and 2.4 MJ respectively. The treatments have significant effect on energy consumption at 5% level of significant. Linear model is fit to express the relationship (Equation 4). Coefficient of determination R^2 of the model is high (0.948). Significant model terms of the equation were variety and quantity (Table 4). This is a revelation

that variation in cooking method as no significant effect on energy demand. Figure 3 shows visual illustration of the relationship.

$$E = 3.445 - 0.195V - 0.125M + 0.705Q \qquad 4$$

4.0. CONCLUSION

This study has shown that variety of rice, cooking method and quantity determine the time, energy and water requirements in rice cooking. Co-efficient of determination of the regression equations (R^2) is high, indicating fitness of the model. Thus, the model is reliable and applicable.

REFERENCES

Abubakar M. S., Umar B. and D. Ahmad (2010). Energy use patterns in sugar production: a case study of savannah sugar company, Numan, Adamawa State, Nigeria. Journal of Applied Science and Research, 6, 377-382.

Abulude, F.O. (2004). Effect of processing on nutritional composition phytate and functional properties of rice (*Oryza sativa)* floor. Nigeria Food Journal 22, 97-108.

Atul M., Sudhir J., Ashok P., Naren R.and K. Anilkumar (2010). Elucidation of unit and operations energy consumption pattern in small scale cashew nut processing mills. Journal of Food Engineering, 99, 184-189.

Jekayinfa S. O. and A.I. Bamgboye (2006). Estimating energy requirements in cashew nut processing operations. Energy, 31, 1305–1320.

Jekayinfa S. O. and A.I. Bamgboye (2007). Development of equations for estimating energy requirements in palm-kernel oil processing operations. Journal of Food Engineering, 79, 322 329.

Khatoon (2006). Nutritional quality of microwave and pressure cooked rice (*Oryza sativa)* varieties. Food Science and Technology International, 12, 297-305

Le-bail A., Dessev T., Jury V., Zuniga R., Park, T. and M. Pitroff (2010). Energy demand for selected bread making processes: conventional versus part baked frozen technologies. Journal of Food Engineering, 96, 510-519.

Mrini M., Senhaji F. and D Pimentel (2002). Energy analysis of sugar beet production under traditional and intensive farming systems and impacts on sustainable agriculture in Morocco. Journal of Sustainable Agriculture, 20, 5–28.

Osaratin A.T. and C. O. Abosede (2007). Effect of cooking and soaking on physical characteristics, nutrient composition and sensory evaluation of indigenous and foreign rice varieties in Nigeria. African Journal of Biotechnology, 6, 1016-1020.

Sanni, S.A, Okeleye, K.A, Soyode, A.F and O. C. Taiwo (2005). Physio-chemical properties of early and medium maturing and Nigerian rice varieties. Nigeria Food Journal 23, 148-152.

Table 1. Design matrix and responses

Variety	Actual Method	Quantity	Variety	Coded Method	Quantity	Time (min)	Water (g)	Energy (MJ)
Ofada	Open	173	-1	-1	-1	47	329.2	2.8
Ofada	Open	692	-1	-1	1	75	1726.0	4.5
Ofada	Close	173	-1	1	-1	45	335.2	2.7
Ofada	Close	692	-1	1	1	69	1731.8	4.1
Bida	Open	173	1	-1	-1	42	433.9	2.5
Bida	Open	692	1	-1	1	67	742.4	4.0
Bida	Close	173	1	1	-1	40	435.9	2.4
Bida	Close	692	1	1	1	61	751.3	3.7
Royal	Open	173	0	-1	-1	54	635.0	3.2
Royal	Open	692	0	-1	1	72	1986.0	4.3
Royal	Close	173	0	1	-1	46	570.0	2.8
Royal	Close	692	0	1	1	71	1993.4	4.3

Table 2. Analysis of variance of linear regression model for time requirement

Model	Un coefficients B	standardized Std. Error	standardized coefficients Beta	t	Sig.
Constant	57.417	1.008		56.948	0.000
Variety	-3.250	1.235	-0.211	-2.632	0.030
Method	-2.083	1.008	-0.166	-2.066	0.073
Quantity	11.750	1.008	0.936	11.654	0.000

Table 3. Analysis of variance of linear regression model for water requirement

Model	Un coefficients B	standardized Std. Error	standardized coefficients Beta	T	Sig.
Constant	972.503	121.107		8.030	0.000
Variety	-219.846	148.326	-0.278	-1.482	0.177
Method	-2.902	121.107	-0.005	-0.024	0.981
Quantity	515.978	121.107	0.800	4.260	0.003

Table 4. Analysis of variance of linear regression model for energy requirement

Model	Un coefficients B	standardized Std. Error	standardized coefficients Beta	T	Sig.
Constant	3.445	0.060		56.949	0.000
Variety	-0.195	0.074	-0.211	-2.632	0.030
Method	-0.125	0.060	-0.166	-2.066	0.073
Quantity	0.705	0.060	0.936	11.654	0.000

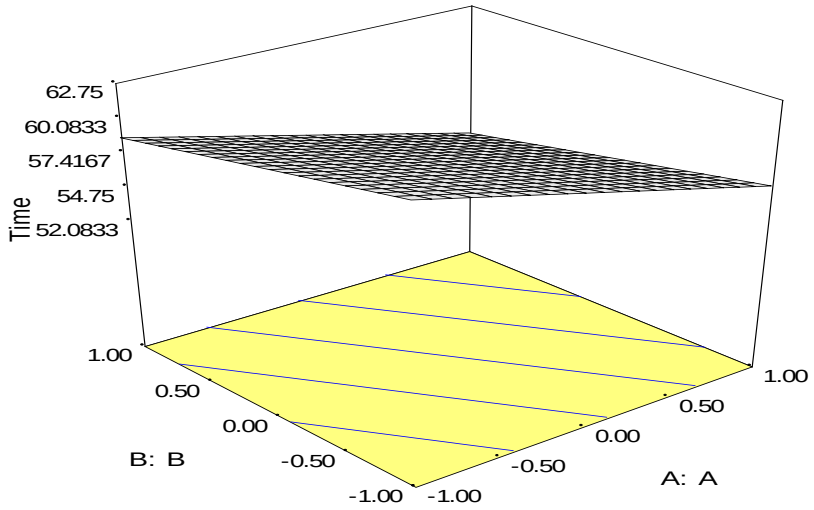


Fig. 1. Response surface plot of treatment against cooking duration

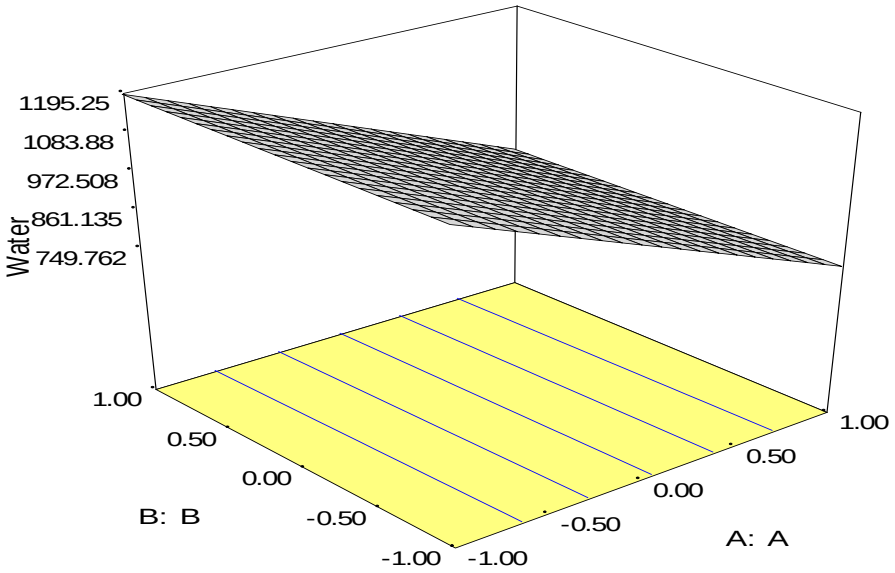


Fig. 1. Response surface plot of treatment against water quantity

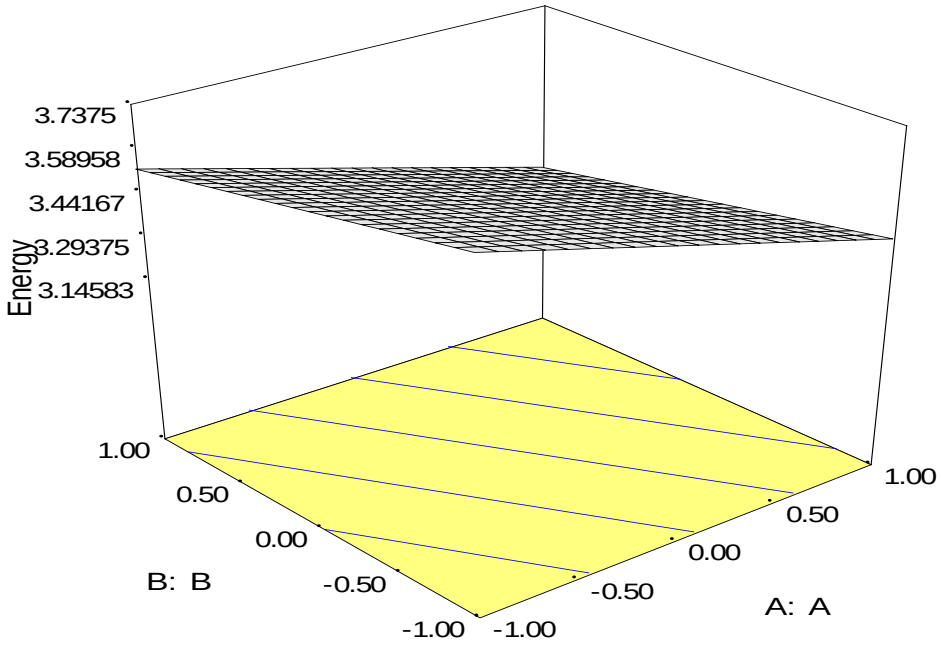


Fig. 1. Response surface plot of treatment against energy demand

SECTION IV

FARM STRUCTURES AND ENVIRONMENTAL CONTROL ENGINEERING

ENGINEERING STRUCTURE IN A TYPICAL SMALL SCALE COCOA PROCESSING INDUSTRY IN ILE-OLUJI, ONDO STATE OF NIGERIA

Omoniyi, T. E[1], Akinyemi B.A[2]. Olasoji O.M.

Department of Agricultural and Environmental Engineering, Faculty of Technology,
University of Ibadan. Oyo State, Nigeria
[1]E-mail: temidayoomoniyi@gmail.com
[2]E-mail: bantonbows@gmail.com

ABSTRACT

This paper explicitly gives the details of the engineering structure of an integrated process plant for cocoa production. The paper covers the pretreatment of the raw cocoa beans to the sequential analysis of each machine involved in the production process of the cocoa processing plant. The processes involve are: testing, moisture determination, separation from foreign materials, destoning stage, micronzing phase, spark arrestor, crushing, roasting of nibs, alkalization, milling, extraction of kibble and the eventual packaging of the cocoa powder into bags. The plant has an installed capacity of converting 20 metric tonnes of cocoa beans/day. The actual output is 16 metric tonnes of cocoa beans/day which comprises both cake powder and butter in the ratio of 8.3: 7.7 which is an 80% recovery from the raw cocoa beans the remaining are wastes.

Keywords: cocoa, cocoa beans, cocoa seeds, process

1.0 Introduction

Cocoa, *Theobroma cacao L.*, is a major cash crop cultivated in the tropical regions of West Africa, the Caribbean, South America and Asia. In West Africa, where over 70% of the world's cocoa is produced – with about 21% coming from Ghana - it is a significant component of the rural economy, as the industry is dominated by large numbers of smallholder peasant farmers who depend on the crop for their livelihood (Acquaah, 1999; Appiah, 2004).

Cocoa bean was the foremost Nigerian foreign exchange earner before the advent of crude oil and it is currently in the second position after petroleum. The annual production in Nigeria is about 165,000 metric tonnes (MT) (Akinyeye, 1999). A small percentage of the annual production is processed, locally, to cocoa butter and cocoa cake, whilst the bulk is exported. The cocoa beans of commerce are the seeds of the tree –Theobroma cacao (Linnaeus), properly harvested, fermented and dried. It originated from Latin America about 500 years ago and thence to Europe, from where it was introduced to other parts of the world (International Cocoa and Commodities Organisation, 2000).

Cocoa in the raw form is not consumable and in the economic sense it has no value. In order to make cocoa consumable and valuable it has to undergo different stages of processing ranging from primary to intermediate and final processing. Since cocoa pods and wet beans are highly perishable in the raw form, it cannot be stored. Even if properly stored, dried cocoa beans can be kept only up to a maximum period of one year. But the intermediately processed cocoa butter can be kept without any damage for a very long time. This gives an additional significance to cocoa processing. The demand for cocoa is entirely derivative which means that it could be derived from the various products of cocoa that are manufactured for consumption. If cocoa production

exceeds cocoa consumption there will be a stock of unprocessed cocoa beans which can depress its price (Theodoro, 1979,). Some of agricultural produce are faced with problems of storage and processing because these produce are easily get spoilt, damage or destroyed (Adejumo, 2007).

Cocoa trees begin to bear fruit when they are three to four years old, the trees are carefully pruned so that pods can be more easily harvested. Cocoa pods are ripen to a rich golden orange colour , within each pod there are 20-40 purple , 2cm long cocoa beans covered is a sweet white pulpy (Kraft, 2012). The harvesting of cocoa pods are labour intensive, though it remains a valued commodity. Ripe pods are gathered every few weeks during the peak season. The high pods are cut with large knives attached to poles, taking care not to damage nearby flowers or buds. Sometimes, cocoa pods are broken with blunt force by striking on a rock. The pods are collected in large baskets, which workers carry on their heads and piled up ready for splitting. The processing of the cocoa seeds, also known as cocoa beans, begins when the harvested fruit is fermented or cured into pulpy state for three to nine days. The cocoa beans are then dried in the sun and cleaned in special machines before they are roasted to bring out the chocolate flavor. According to Kraft food 2012, fermentation methods vary considerably from country to country, but there are two basic methods that are often used are heaps and sweating boxes. The major problem faced by agricultural fruits against surplus production is that they are prone to damage, and this called for serious and adequate attention of a functional preservative mechanisms in which researchers and scientist have been able to develop (Adenubi, 2011) and still working on.

One of the possible methods of curbing wastages in most agricultural fruits is to process them into concentrate by drying, which is now used for cocoa powder production. Cocoa seeds are used for production of cocoa powder. This is later processed into bournvita, chocolate, cocoa butter and is greatly consumed by human beings. Besides their nutritional benefits, establishment of such industries or companies that processes them will bring about huge benefit not only for entrepreneurs but also to the whole populace. It could as well boost the economy of this great Nation. Most importantly, investing in such industries or establishing such industries by the federal government or individually, will assist in job creation, and gradually help in securing jobs for unemployed graduates.

2.0 Materials and Methods.

The engineering structure of the Industry was investigated, the man-machine environment was observed. Each process was carefully considered. The sequences for the processing of cocoa beans into powder are outlined below.

2.1 Testing

This is a physical examination test prior to the real processing; the analysis includes among others moisture content, odour, evaluation and cutting test. Most of these analyses are carried out by the quality control people for a quality testing. Beans with high moisture content have been dried insufficiently and therefore have short shelf life, number of beans per 0.1kg is counted (beans count) as well as the % of beans. A cut test is then made on each batch of cocoa beans. One batch of 500 sacks was tested by one cut test. Samples from each bag were mixed and separated randomly till 100-200 beans remained. More than 500 sacks should be tested with three cut tests. Moisture content was measured with moisture meter and the size of beans was determined by beans count, where 100g of cocoa beans were weighed and counted. Also the

percentage dust and foreign matter has to be within maximum limits. The final test concerns the cutting test where 300 beans are split into halves and the colour of the cross section is judged, among others, the percentage of slate and violet coloured beans is determined. All beans purchased are usually tested to ensure quality standards, at times 4 samples are combined and are tested chemically. Fat content, PH and the free fatty acid (FFA) content are important for the production of cocoa mass. The PH value is indicative for proper fermentation, which allows for desired cocoa flavor and colour to be produce.

2.2 Moisture Content and Relative Humidity of Cocoa Beans

Biological activity occurs only when moisture is present, the moisture content of the product itself as well as the moisture content of surroundings air are important for safe storage. Each product has its own characteristics balance (or equilibrium) between the moisture it contains and the water vapour in the air surrounding it. The moisture content of a product is expressed as a percentage of the Wet weight (W_w basis):

$$\text{Moisture Content (\%)} = \frac{Ww - Wd}{Ww} \quad \text{x} \quad 100\%$$

$$\text{Relative Humidity (\%)} = \frac{Amount\ of\ water\ vapour\ in\ the\ air}{Maximum\ amount\ of\ water\ vapour\ in\ air\ at\ aparticular\ temp} \text{ x } 100\%$$

Cocoa beans are in equilibrium with air at a relative humidity of 70% and with a moisture content of 8%. If relative humidity of the air decreases to 40%, the cocoa beans will lose moisture until a new equilibrium is reached, the moisture content of the beans will decrease to 6%. The maximum allowable moisture content is taken to be the equilibrium which corresponds to a relative humidity of 65-70%.When a product‘s moisture content is equal to or below the safe moisture content, the danger of attack by bacteria and fungi is negligible.

2.3 Separations of Cocoa Beans from Extraneous Materials

At this section cocoa beans are inspected and thoroughly cleaned of any dirt or debris that might have fallen into sacks such as sticks stones or broken beans. This section prevents contamination of the end product, and it makes use of pneumatic and magnetism method of operation, the machine is known as Beans Cleaning Machine as shown in Plate 1. The cocoa beans are discharged into hopper and later transferred through cup elevator, the lighter material are removed from the beans through the aid of aspiration fan while the magnet attract and separate metallic materials such a broken nails irons. All these unwanted materials are passed into a cyclone through the means of suction pipe and about 60 tonnes of cocoa beans are discharged into this hopper.

2.4 Destoner Machine

The machine serves two main purposes which are to remove stones and big metals such as nails. Mechanism of operation is through agitation and vibration; cocoa beans are discharged on a sieve through cup elevator which is attached to the machine at the front as shown in Plate 2. Sometimes, extraneous materials which escaped cleaning machine are trapped here. Also, destoner machine makes use of aspiration fan to carry the basic operation efficiently. Its components are not different from that of cleaning machine expect use of sieves. It was observed that the machine should be well agitated by increasing the speed.

2.5 Micronizing the Cocoa Beans

Cleaned beans get to micronizer machine through a screw conveyor into cup elevator and later into silo (about 10tonnes) and pass into the drag chain conveyor. The micronizing bed has about 4.2 tonnes. The hopper is designed to be located in the head which allows even spread on the bed. The infra red heat treatment on cocoa beans gives a large average nib's size with reduction in moisture content as a result of further drying. Moisture content of about 2% to 3% is lost from initial moisture content of 7.5% due to even heat distribution, micronized beans are split approximately 40% of shells. However contamination of yeast, mould and bacteria are lowered. Internal temperature of 100°C to 110°C is set along with time frame of 60 to 180 seconds, and these depend on the origin of the beans. Micronizing machines are operated from electrical panel board with vibration techniques so that the beans are turned while they are being heated and this will allow effective separation of chaff and cotyledon (breaking of bond). The components are vibrating conveyor, infrad red manifold, 5mm stainless bed, hydraulic elevator system, panel board, and steel frame. Plate 3 shows the micronizer and it must be well vibrated for efficient performance.

2.6 Spark Arrestor

A spark arrestor isolate and prevents fire hazard while the machine is in operation, it also regulate heat so that there will not be any record of burnt beans. The machine is made up of chamber fitted vertically with mounted shaft and four paddles type blades which stir clock wisely at 8 rpm. The spark arrestor (Plate 4) will be more effective if the paddles blades are increased from four to six blades.

2.7 Crushing into Nibs (Winnowing)

Generally in food processing, winnowing refers to the process in which the beans are cracked and the shell portion of the beans is removed, leaving only the portion or nibs. This is a size reduction machine which crushes the soft rubbery texture of cocoa beans into nibs with the aid of a cracker (a strong steel bar) along with an electric motor. The cracker has two bearings which housed the steel bar (trapezoidal shape). Suction pipes are incorporated which suck the shells of cocoa beans into outlet channel. The broken nibs are separated into various size channels making use of rake arms and transferred through channels of different sizes and into the silo with a capacity of 3 tonnes of nibs. During the process of operation, the nibs are passed into screw conveyor and later through silo which lead to roaster section. The component are; raked arms, sieves electric motors, cup elevator, main cracker, return cracker house, suction fan with pipes and steel frame. Winnowing process provides on the average 78-80% nibs, 10-12% shells, with a small amount of germs and 4% of fine cocoa particles as waste. All yields are calculated on the basis of the weight of the raw beans. For effective performance of this machine, the capacity can be increased from three to four tonnes of nibs and also the vibration of the machine (Plate 5) can be increased by adjusting the belt of the electric motor.

2.8 Roasting of Alkalized Nibs

The controlled roasting atmosphere allows the flavor to be uniformly intensified, roasting drum which rotates at 360° (mechanically) reduce the moisture content of nibs to 2%. Roasting machine is often operated from a computerized panel board and process is batch by batch due to limited capacity of about 2.6 tonnes (2600kg). The inner part of the drum is usually lagged with

materials that prevent escape of heat and allow for even distribution of heat to take place. Nibs are roasted to a temperature of 118°C with aid of punks attached to an injector pipe which sprays water during roasting and for 35 or 60 minutes depending on the specie of the beans. Sometimes, the actual roasting time depends on whether the end use is for cocoa powder or chocolate. During roasting, the nibs become darken in colour and acquire flavor and these characteristics started to develop. The roasted nibs are discharged into cooler, this assist in cooling the nibs through stirrer, and to allow for even distribution of nibs while discharging from the roasting drum. Moreover, efficient functioning of the cooler prevent problem of coagulation. Nibs should not stay more than 10minutes before it is transferred to refinery section through a suction pipe using pneumatic techniques and a rotary lock regularize the discharge into the hopper of pre-grinders.

2.9 Alkalization of Cocoa Nibs

Alkalization is a process where nibs, chocolate liquor or crushed press cake (coarse cocoa powder) is treated with a suitable alkali solution and subsequent to alkali treatment; the moisture is removed during drying, micronizing and roasting process. Cocoa powders derived from these processes are referred to nib- alkalized cocoa, liquor –alkalized cocoa or cake alkalized cocoa (powder–alkalized cocoa).The nibs' alkalization provides the best option there, there is less detrimental impact on the composition of nibs during alkalization because the components of the nibs are still in their natural state. Alkalization of cocoa nibs performed three main purposes, which are to neutralize the acidity of the cocoa beans and remove flavor, to promote reaction between cocoa pigment, and to promote flavor development by promoting reaction between protein and reducible sugar present in the cocoa beans.

2.10 Milling of Nibs

The process involves three stages which are; pre-grinder (beater blades, mid grinding (ball milling) and fine grinding (Spindle milling in Plate 6). The grinders are operated with electric motors and screw motor. Motors are attached to the hopper which controls the movement of nibs into the beater blades. Nibs are transformed into paste (liquor mass) which swims of its own fat because no water is added. The beater blades and ball mill machines are used for milling operation in the first stage of milling the nibs while final stage of milling is done with the use of spindle mill. These machines make use of electric motors, pump motors and screw motors to carried out the milling process. The machines are designed such that the feeds are attached on top of the grinders for smooth conveying of nibs into respective channels. Operation process is done through automation system, there is no need of winning of any motors expects the motors are no longer functioning, and these are replaced with new ones so that processing will not be delayed.

2.11 Extraction of Kibble cake from the Press Machine

Hydraulic presses shown in Plate 7 is used to produce kibble cake and cocoa butter and this also called the filter press. Homogenizer which is attached along side with the press machine allows for easy mixture and filtration in the press machine, the temperature of the homogenizer is around 110 to120°C. Prior to pressing, it is very important that liquor stays inside measuration tanks (20 tonnes capacity) for 12 hours at a temperature of 90°C with continuous stirring so that the liquor will not cake up. The moisture Content is drastically reduced to 1% at this section so that the fat content of liquor will be preserved. The kibble cakes are prepared by hydraulic pressing of finely ground cocoa powder. This is achieved by compressing the liquor in heavy steel pots until a

predetermined amount of cocoa butter is squeezed through a very fine mesh screens or filter situated at each side of the pot. Each pot has a capacity of about 18kg and mounted on a horizontal frame. Cocoa liquor is heated to 93 -102°C and pumped in at a pressure of 400 to 500 bar, cocoa butter starts to be forced out through the filter screens and when the pots are full, the pressure pump is turned off, then the hydraulic rams are set in motion at pressure of 700 bar. The kibble cakes are discharged at this temperature from each pot and immediately they convey by belt conveyor for pulverization.

2.12 Pulverization of Kibble Cake

The major machine used is the kibble machine; peg mill machine can be use as well. The stone hard cocoa cake with a residual fat content of 10 to 24% is disintegrated by rollers with intermeshing teeth, grind in a peg mill and separated into fine fraction by air sifter. The pre-breaker is designed to accept lumps up to 150mm in diameter and reduce them to 2-3mm in diameter. A flap is incorporated to regulate itself mechanically for the opening and closing of discharge unit and weight is set at 25kg if it is required that the broken piece should be packed.

2.13 Milling coarse Fraction into Powder

Powder grinding lines pulverize cocoa cake particles into the defined fineness levels, the cone mill are often used because it is ideal for intermediate size reduction. This is a low energy mill, gentle and capable to control fine limits while maintaining a close particle size distribution. However, the kibble cakes are distributed by the classifier machines. After pulverization, the powder is blown into the discharge unit while cooling is taking place by a cooling compressor. The cooling process prevents discolouring (fat bloom) and lumps forming in the bags later, a phenomenon that is caused by insufficient crystallization of the fat at the moment of filling. Next free flowing powder is passed through sieves and over magnet prior to packing in paper bags or in bulk or small containers. Based on geographical locations, the cocoa powder is usually packed in paper logs of either 25kg or 50lbs and 1000kg for big bag. These bags are made of multi-layer kraft paper and polyethylene moisture barrier. The packing process is shown in Plate 8.

3.0 RESULTS AND DISCUSSION

3.1 DISCUSSION

In the production of cocoa beans into powder, Table 1 was the result gotten, based on fat content cocoa powder are classified into three categories based on their percentage composition.

Also cocoa powder are categorized as medium, low and high fat content as shown in Table 2.

To measure product quality, there is need to monitor sales and consumer complaints. The higher the sales, the fewer the complaints and vice-versa. Product quality is usually based on alkalization of nibs, aroma, taste, colour, fat content, moisture content and residues. Cocoa powder is more sensitive to alkalization; a strong alkali treatment to liquor can lead to detrimental effect on cocoa butter as well as cocoa powder. In powder, the non fat components especially protein and starch are concentrated because fat is removed and they are subjected to maximum exposure due to particles size reduction from grinding to powder. A slight change in colour may lead to poor quality and these affect sales. The colour of the nibs varies from light orange to yellow to dark reddish brown.

The plant has an installed capacity of converting 20 metric tonnes of cocoa beans/day. The actual output is 16 metric tonnes of cocoa beans/day which comprises both cake powder and butter in the ratio of 8.3: 7.7 which is an 80% recovery from the raw cocoa beans the remaining are wastes. The Industry operates for the entire year on the shift basis; the machines and worker operate 8 hours in a day. The wastes are sold off for export.

4.0 CONCLUSION

Cocoa powder can stay up 24 months in the original package and it should be kept in a cool, dry storage which is free from foreign materials and bad odours.

REFERENCES

Acquaah, B. (1999): Cocoa Development in West Africa (The Early Period with particular reference to Ghana), Ghana Universities Press, Accra, Ghana)

Appiah, M. R. (2004): Impact of Cocoa Research Innovations on Poverty Alleviation in Ghana. Ghana Academy of Arts and Sciences Publication. pp1, 17-19.

Akinyeye, R. O. (1999). Causes of capacity under-utilization in cocoa processing industries in Nigeria. Akure, Nigeria: MBA Thesis, Federal University of Technology.

International Cocoa and Commodities Organisation (2000). ICCO celebration of cocoa 2000. London: K.P. Partners in Publishing.

Theodoro K. Markham, 1979, Activities of Transnational Corporations in the Cocoa Industry in Ghana, Working Paper No. 5, Economic Commission for Africa – Joint ECA/CTNC Unit on Transnational Corp.

Adejumo Abosede 2007**,** Personal communication on Effective Cleaning of Agricultural Produces, 2007. Unpublished Lecture Material, LAUTECH, Oyo State.

Kraft Food Australia (formerly Cadbury Pty Ltd) Pty Ltd, 2012.

Adenubi Kehinde Oluwatomi 2011, Fruit Juice Production seminar project, A case study of Fumman Agricultural products industries Limited.

Table 1: Fat content distribution and usage

Fat content	**Uses**
20-22%	Used in beverages for sensory reasons because it is mouth coating
10-12%	Standard powder without mouth coating or feeling
0%	This is used by beverages manufacturers to alter certain properties of the Powder.

Table 2: Cocoa powder categorization

Fat classification	**Powder content (%)**
Low fat	10 – 12
Medium	16 -18
High fat	22 - 24



Plate 1: Beans Cleaning Machine at Cocoa Products Ile- Oluji



Plate 2: Destoner machine at Cocoa products in Ile-Oluji



Plate 3: Micronizer machine being observed at Cocoa products in Ile-Oluji



Plate 4: Spark Arrestor



Plate 5: Winnowing Machine at Cocoa Products



Plate 6: Spindle Mill atCocoa Products in Ile-Oluji



Plate 7: Hydraulic press used for kibble cake production



Plate 8: A view of packaging machine of Cocoa Powder in the Cocoa Products in Ile-Oluji

PERFORMANCE CHARACTERISTICS OF GUM ARABIC BONDED PARTICLEBOARD MADE FROM RICE HUSK

Ndububa E. E.
Department of Civil Engineering, The Federal Polytechnic, P.M.B 0231, Bauchi. Nigeria.
E-mail: ndububaee@yahoo.com

ABSTRACT

Rice husk materials were combined with gum arabic (acacia leguminosae) as adhesive resin to produce particleboard samples. The resultant Rice Husk Particleboard (RHP) samples were subjected to flexural, tensile, compressive, water absorption and permeability tests to confirm their mechanical performance as building and structural materials. Increase in the gum arabic content from 15% to 35% by weight of RHP improved the flexural strength (measured as modulus of rupture) from 3.82to 14.58 N/mm^2. The tensile strength (internal bond), density and compressive strength also increased from 0.18 to 0.34 N/mm^2, 546.2 to 809.5 kg/m^3 and 0.69 to 3.13 N/mm^2 respectively. The results showed that RHP equaled the European standards for flexural and tensile strengths when the proportion of gum arabic was 30%. The European general requirements are 11.5 N/mm^2 and 0.24 N/mm^2 for bending and axial strengths respectively. The compressive strengths at 35% resin exceeded 2.5 N/mm^2 (the minimum acceptable compressive strength of sandcrete blocks according to Nigerian Standards Organization). The coefficient of permeability value of $2.12x10^{-7}$ m/s for resin proportion of 35% fall within the range specified as low degree of coefficient of permeability for soils, which is $10^{-5} – 10^{-7}$ m/s. The maximum density of 809.5 kg/m^3 places RHP as a lightweight building material. However the water absorption capacity value of 7.9% for 35% resin soaked for 2 minutes is far higher than the average specified value of 0.66% by European standards. RHP may be useful as internal partition wall material and as internal ceiling board. Further study may be done on increased gum arabic proportion, additives impregnation to reduce water absorption and determining other physical properties like sound proofness, thermal conductivity and nailability.

Keywords: Particleboard, rice husk, gum arabic, strength.

1. INTRODUCTION

Fibreboards include hardboards, Medium Density Fibre (MDF) boards and particleboards. Particleboard is an engineered panel product in which particles of wood are bonded together to form a panel. Most conventional particleboards are produced from wood-based materials, which are formed by using a synthetic resin adhesive. Particleboards are used as ceiling boards and partitions in the building industry. They are usually imported and expensive in Nigeria. There is therefore the need to explore the possibility of making them cheap in the country. The major objective of this study as reported in this paper is to explore the viability of locally sourced and natural gum arabic as an adhesive binder for the production of particleboard from readily available agricultural waste products, such as rice husks.

Industrial manufacturing process of particleboards involves the drying and screening of the wood/fibre particles or flakes. The resin is then sprayed through nozzles on to the particles which are then formed into sheets under pressure. Common industrial adhesives are urea formaldehyde resin, melamine formaldehyde resin and phenol formaldehyde resin. They are relatively expensive. These resins are sometimes mixed with other additives before being applied

to the particles in other to make the final product waterproof, fireproof, insect proof or to give it some other qualities. Once mixing is done, the mixture is made into a sheet. The sheets are compressed under high temperature (1400^oC - 2200^oC) and pressure (2MPa – 3MPa) to reduce their thickness, set and harden the glue (resin). The cooled boards are then trimmed and sanded to be sold either in an untreated form or covered in a wood veneer. Other types of particleboards made from synthetic fibres, cement bonds and gypsum plasters are relatively costly (Wikipedia, 2007), (Japhet, 2007).

Rice husks are agricultural post harvest wastes from the whole rice seeds. They constitute the covering of the seeds which are separated from the seed after milling. They are usually fed to cattle and sometimes left as wastes in the open, and therefore constituting nuisance and environmental hazard. They can also be used as fuel, poultry bedding and then re-used as organic fertilizer.

Gum arabic is the hardened sap of the acacia Senegal tree (botanical name: acacia leguminosae) which is found on the swath of arid lands extending from Senegal on the west coast of Africa all the way to Pakistan and India. It has variety of applications, some of which are as additives and thickners in foods and beverages, pharmaceuticals and cosmetics. It has binding and stabilizing properties, among others. It is found in Northern Nigeria.

Non–wood fibres, particularly those derivable from agricultural wastes have also been used to produce particleboards. Wang and Sun (2002) had identified agricultural residues as renewable resources which can be used as raw materials for producing particleboard.

Research work has been done on a wide variety of agricultural residues from different regions of the world. Some of the residues include wheat straws (Mosesson, 1980), coir (Ndububa, 2000), groundnut shells (Jain et al, 1967), bamboo (Rowell and Norimoto, 1988), tea leaf waste (Yalinkiling et al., 1998), bagasse (Mitlin, 1968), sunflower stalks (Khristova et al., 1998), and palm fruit fibre (Ndububa et al., 2001).

Previous reports on particleboard research showed that rice straw –wood composite particle board had higher modulus of rupture and lower density than conventional wood based particleboard (Yang et al, 2003), smaller particles decreased the static bending and modulus of elasticity (Mottet, 1967), low particle moisture content decreased the mechanical properties (Kolman et al, 1975) and particle dusts between voids increased the shelling ratio, thereby improving the physical and mechanical properties of particleboard (Gokay, 2003). Also increase in percent ratio of gum arabic in ground maize cob and sawdust/wood shavings matrices improved the mechanical properties of the particleboard produced from the mixtures respectively (Ndububa et al., 2006), (Ndububa, 2010).

Due to the high cost of conventional resins and woods used in the production of particleboards, there is the need to explore cheaper alternative materials in post harvest residues and gum arabic. The tests carried out on the particleboard from these materials are flexural, tensile and compressive strengths. Others were density, water absorption capacity and permeability.

2. MATERIALS AND METHODS

Rice husks were collected from a rice milling facility in Bauchi, North East Nigeria, while the gum arabic was obtained from a neighbouring state of Yobe, also in North East Nigeria. Gum arabic content was varied from 15% - 35% at intervals of 5% by weight for each tests. For each proportion of gum arabic, five samples were produced in the laboratory.

2.1 Preparation of Materials

The rice husk was pounded with mortar and pestle to smaller particles and sieved through British Standard (BSI, 1990) meshes of 3, 1.5 and 0.8 mm apertures to remove oversize and undersize particles. Congealed gum arabic was ground and broken up before diluting with water to form a liquid resin adhesive in a gum/water ratio of 4:1 by weight. The water was expected to be evaporated during heat treatment.

2.1.1 Mixing (Blending) and Forming

The liquid resin and the rice husk sample were mixed and blended together manually in the laboratory. The blended mix was then transferred into a 100 x 100 x 50 mm mat formwork made with steel material. Tamping was done to give a "formed mat" which was covered up with a steel metal and placed in a "Memmert" Universal" oven (series u – ul 1992 model, France). The temperature was raised up to 150^{o}C, enough to evaporate the water content and dry the samples. The liquid resin content was varied from 15% to 35% of particleboard weight for sets of experimental samples.

2.1.2 Heat Treatment and Compaction

At 150^{o}C when the water content in the resin had evaporated, the boards were pressed with the "Perrier Maurice" compression machine (Perrier Maurice/Sodeteg, 1981, France) at 2.6–3.0 N/mm^2 pressure for 7 minutes, reducing the thickness of the particleboard samples to an average of 12 mm. After pressing and in accordance with European standardization requirements (EN 312 –2, 1996), the particleboards were placed again in the oven and conditioned for two days at an equilibrium and curing temperature of 26 $\pm$ 2^{o}C with an average humidity of 68% using the oven temperature indicator. This was monitored at 6 hourly intervals before testing

2.2 Characterisation of Experimental Particleboard

2.2.1 *Flexural Strength (Modulus of Rupture) Test*

Samples for flexural test were 100 x 30 x 12 mm in size. Centre point loading was applied on a "Perrier Maurice" Bending machine (Perrier Maurice/Sodeteg, 1981, France). Tests were conducted in accordance with EN 310 (1993). The Modulus of Rupture was taken as a measure of the Flexural Strength as given by Neville (2003) and calculated from the formula:

$$T_b = \frac{3WL}{2bt^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where $T_b$is Modulus of Rupture in (N/mm^2), W is load at failure in (N), L,b and t are respectively the length, breadth and thickness of the samples in (mm).

2.2.2 Tensile Strength Test

Tensile strength tests were conducted by subjecting the specimen to tensile stress with a tensometer. Failure occurred by splitting. The splitting tensile strength T is obtained (Neville, 2003) from the expression

$$T = \frac{W}{bt} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where W in (N) is the maximum applied load, band t in (mm) are the breadth and thickness of the samples, respectively.

2.2.3 Compressive Strength Test

The compressive strength test was carried out in accordance with the specification of EN 310 (1993) and EN 319 (1993). The specimen were cast into cubical sizes of 12x12x12 mm before being placed on "Perrier Maurice" compression machine with 1500 KN capacity. The samples were placed on the machine platen and loaded at 5 bars per second until crushed. The machine indicator stops at failure load, which was then read off from the indicator. The compressive strength T_c was calculated (Neville, 2003) from

$$T_c = \frac{W_c}{bt} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Where W_c in (N) is the failure load, b and t are the breadth and the thickness of the samples in (mm) respectively

2.2.4 Density

The weights of the test samples subjected to compressive strength were also taken by weighing on a "Mettler PC 2000" electronic machine (Sodeteg, 1981, France). The machine has weight range of 5 to 2100 grammes. The values obtained were divided by the compressed volume (12 x 12 x 12 mm) to determine their true densities (Neville, 2003).

2.2.5 Water Absorption

Samples of the RHP of known weights (initial weight) were immersed in water at room temperature. They were brought out and re-weighed at 2 minutes intervals until they reached saturation points when the weights ceased to change (ASTM D-1037, 1978).

Water Absorption Capacity at any time WAC is taken as

$$WAC = \frac{\text{Weight at given time - Initial Weight}}{\text{Initial Weight}} x100\% \quad \ldots\ldots\ldots \quad (4)$$

2.2.6 PermeabilityTest

The falling head permeability test was adopted. Water was allowed to run through specimens and observations made by monitoring the rate of fall of water in the manometer tubes. Coefficient of permeability was determined (Terzaghi and Peck, 1967) from the equation (5)

$$K = \frac{al}{A(t_2 - t_1)} \log_e \left(\frac{h_1}{h_2}\right) \quad \ldots\ldots\ldots\ldots\ldots (5)$$

Where **a** is the area of standpipe in mm^2, **A** is the area of core cutter of the cell in (mm^2), $\mathbf{t_2}$-$\mathbf{t_1}$ is the time taken in running the test in (s), h_1/h_2 is the height ratio and l is the sample length in (m).

3. RESULTS AND DISCUSSION

Figures 1 and 2 shows the respective values of the flexural, tensile and compressive strengthsfor different proportions of RHP. The density values are shown in Figure 3. Trends in the physical properties of water absorption capacity are shown in Figures 4 and 5. The permeability of RHP with 35% gum arabic proportion was $2.12x10^{-7}$ m/s as shown in Table 2. The average modulus of rupture (i.e. flexural strength) of the RHP ranged from 3.82 N/mm^2 to 14.58 N/mm^2 for gum arabic contents of 15 to 35%. The static bending requirement for general purpose boards according to EN 312 – 2 (1996) is 11.5 N/mm^2. The specimen with gum arabic content above 30% had as much flexural strength as with the general purpose requirement. Also average values of test results ranged from 0.18 N/mm^2 to 0.34 N/mm^2 for the tensile strength. The minimum requirement of tensile strength for general-purpose boards according to EN 312 – 2 (1996) is 0.24 N/mm^2. Again the tested RHP specimen had the same strength at 30% gum arabic as with the requirement for general purpose boards. These show that when used as ceiling boards, RHP at 30% gum arabic ratio will be able to bear as much transverse load as the conventional particleboard.

The range of values of the compressive strength test results is from 0.69 N/mm^2 to 3.13 N/mm^2. The minimum acceptable compressive strength for sandcrete blocks in Nigeria according to Nigerian Standards Organization is 2.5 N/mm^2 (NSO, 1975). This shows that RHPs of 30% gum arabic proportion and above may be used as internal partition wall materials in non waterlogged locations. The range of values for density is from 546.2 kg/m^3 to 809.5 kg/m^3. According to British Department of Environment (1973), 1600kg/m^3 is considered the maximum value for lightweight masonry. The RHP therefore easily passes for a lightweight building material. The general trend from the Tables and Figures show that mechanical strength increased with increase in gum arabic content.

While the mechanical strength results show that RHP is a viable building material, the high water absorption capacity is a disadvantage in its use. The EN 312-2 (1996) specification for average water absorption capacity of a standard particleboard is 0.66% soaked for a minimum of 2 minutes and 3.96% soaked for a maximum of 12 minutes, but none of the RHP samples met this requirement. The coefficient of permeability of 35% gum arabic RHP which is $2.12x10^{-7}$ m/s fall within the range of 10^{-5} – 10^{-7} m/s. This range is described as "low degree of coefficient of permeability" for soils as given by Terzaghi and Peck (1967). It is believed that if developed and mass produced, RHP bonded with gum arabic may serve as a credible alternative building material to imported particleboards produced from more expensive synthetic binders and fibres.

Most of the results are found to have met the minimum standards as set up by different Standardization bodies except in water absorption capacity.

4.0 CONCLUSION

This paper presents a report that shows that particle board produced from rice husk, and bonded with gum arabic as the resin adhesive possesses the required mechanical properties of flexure, tension and compression, for applications as ceiling boards and moisture-protected partition walls. This performance characteristic is however enhanced as the gum arabic resin content of the total composite particleboard material by weight is increased. However, the relatively high water absorption capacity and permeability of the RHP has a diminishing effect on the performance.

Further investigations on other performance characteristics of the RHP like dimensional stability, nailability and durability is recommended. Also further tests could be carried with impregnation of additives.

REFERENCES

American Society for Testing and Materials (ASTM, D-1037). "Standard Methods of Evaluating the Properties of Wood-base Fiber and Particle Panel Materials". ASTM. Philadelphia. 1978.

British Standard Institution, BS 1377. "Methods of tests for soils for Civil Engineering Purposes", BS I, London. 1990.

Department of Environment, Britain: Overseas Building Notes No. 152, Manufacture and Application of Lightweight Concrete, London. 1973.

EN 310. "Wood based panels, determination of modulus of elasticity in bending and bending strength". European Standard Committee. Brussels. 1993.

EN 312 – 2. "Particleboards – specifications part 2: requirements for general purpose boards for use in dry conditions". European Standardization Committee. Brussels. 1996.

EN 319. "Particleboard and Fibreboards, determination of tensile strength perpendicular to plane of the board". European Standardization Committee. Brussels. 1993

Gokay, N. "Effects of some manufacturing factors on the properties of particleboard manufactured from Alder (Alnus glutinosa subsp. Barbata)". Turkish Journal of Agricultural Forests Vol. 27. Pp. 99 – 104. 2003.

Jain, N.C., Gupta, R. C and Jain, D. K. "Particleboard from groundnut shells". In: Proceedings 11th Silviculture Conference, India Pp. 141 – 147. 1967.

Jain, N.C., Gupta, R. C and Jain, D. K. "Particleboard from Rice waste". In: Proceedings 11th Silviculture Conference, India Pp. 5 – 8. 1967.

Japhet, A. N: "Mechanical Properties of Gum Arabic Bonded Particle Board made from Sawdust and Wood shavings". Unpublished Project Report. The Federal Polytechnic, Bauchi. Pp. 5-7. 2007.

Kolman, F., E. W. Kuenzi, and A. S. Stam. "Principles of Wood Science and Technology". Springer Verlag. Berlin, Heidelberg, New York. 1975.

Khristova, P. N., Yussifou S., Gabir, I. Glavche, and Osman, Z. (1998).
"Particleboards from sunflower stalks and tannin modified UF resin". Cellul. Chem. Technol. 32: 327– 337. 1998.

Mitlin. L. "Particleboard manufacture and application". Novello & Co.Ltd.
Kent. 1968.

Mosesson, J. G.. "The Processing and use of Waste Straw as a Constructional Material". Conservation and Recycling. 3:389 – 412. 1980.
Mottet. A. "The particle geometry factor". Proceedings of the WSU particleboard symposium. No.1. Pullmann, Wash. Pp. 189 – 195. 1967.
Ndububa, E.E. "Flexural strength of mortars stabilized with vegetable fibres as low – cost materials for Farm Structures". Journal of Agricultural Engineering and Technology. NSAE. Vol.8. pp.21-25. 2000.
Ndububa E. E, "Performance Characteristics of Gum Arabic Bonded Particleboard made from Sawdust and Wood Shavings". Accepted for publication at Ife Journal of Technology, OAU, Ile Ife. 2010
Ndububa, E.E., Mustapha A. B., Jackden D. E. and Ndububa O. I. "Palm fruit fibre mortar as a lightweight structural material for Low Cost Housing". Journal of Engineering Technology and Industrial Application, Vol. 1 (3). Pp. 24 – 25, 2001.
Ndububa E. E, Oke C. O and Ndububa O. I. "Mechanical Properties of Particleboards Produced from Maize Cobs with Gum Arabic as Resin Adhesive Binder". Proceedings of the 7th International Conference of the Nigerian Institution of Agricultural Engineers, Zaria, Nigeria. Vol. 28. 2006.
Neville A. M. "Properties of Concrete." Pearson Education. 4th Edition. Delhi. Pp. 208, 210, 269 and 307. 2003
Nigerian Standards Organization (NSO): Specifications for sandcrete blocks,
Nigerian Industrial Standard, Lagos. P. 11. 1975.
Rowell, R. M. and M. Norimoto. "Dimensional stability of bamboo particleboards made from acetylated particles". Mokuzai Gakkaishi 34 (7): 627 – 629.
Wang, D. & X. S. Sun. "Low density particleboard from wheat straw and corn Pith". Industrial crops and products. Vol. 15: Pp. 47 – 50. 2002.
Wikipedia: http:www.en.wikipedia.org/wiki/particle board. 2007
Yalinkiling, M. K. Y. Imamura, M. Takahashi, H. Kalaycioglu, G. Nemli, Z. Demirci, and T. Ozdemir. "Biological, physical and mechanical properties of particleboard manufactured from waste tea leaves". International Biodeterioration and Biodegration. 41 (1): 75 – 84. 1998.
Yang, H. S. Kim, D. J and Kim, H. J. "Rice straw-wood composites for sound wooden construction materials". Journal of Bioresource Technology, Elsevier South Korea, vol. 86, pp. 117-121, 2003.

Table 1: Flexural, tensile and compressive strengths of Experimental rice husk particleboard (RHP)

Gum Arabic content %	Flexural strength N/mm^2	Tensile strength N/mm^2	Compressive strength N/mm^2	Density kg/m^3
15	3.82	0.18	0.69	546.2
20	6.94	0.20	1.04	604.6
25	9.38	0.21	2.08	617.9
30	11.45	0.24	2.43	701.1
35	14.58	0.34	3.13	809.5

Table 2: Water Absorption And Permeability Of Experimental Rice Husk Particleboard (RHP)

Gum Arabic content, %	Initial sample mass, g	Water Absorption Capacity for specified soaking time (min.)						Permeability X 10^{-7} m/s
		2	4	6	8		10	
15	165.4	20.9	23.0	25.0	25.0		25.0 *(206.8)**	
20	155.7	19.3	21.0	23.6	23.6		23.6 *(192.5)**	
25	146.0	12.6	14.0	16.1	16.1		16.1 *(169.5)**	
30	136.3	9.0	10.8	12.3	12.3		12.3 *(153.1)**	
35	126.5	7.9	10.1	10.8	10.8		10.8 *(140.2)**	2.12

* Final sample weights (in grammes) at saturation points are given in parentheses

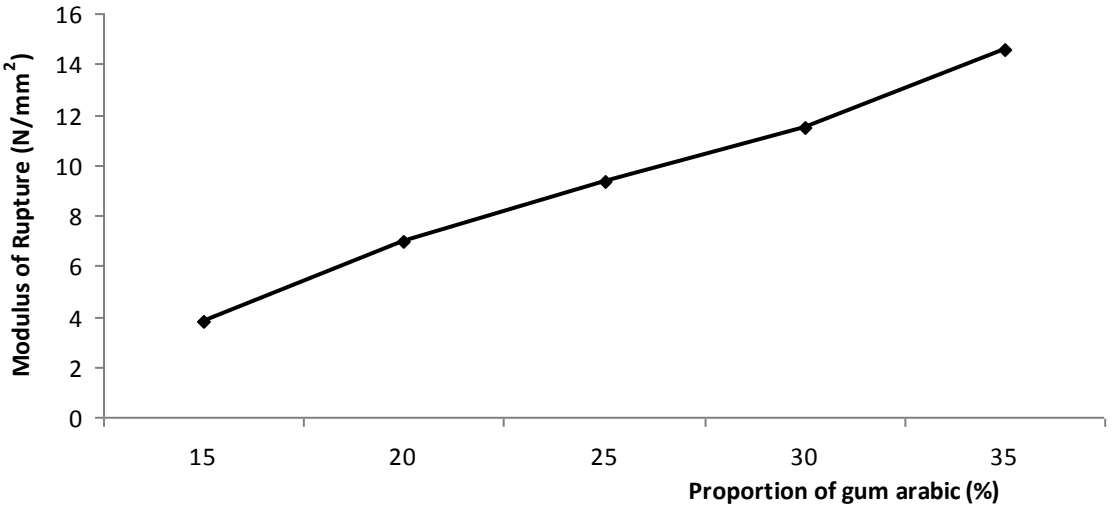


Fig. 1: Flexural strength of RHP with different proportion of gum arabic binder

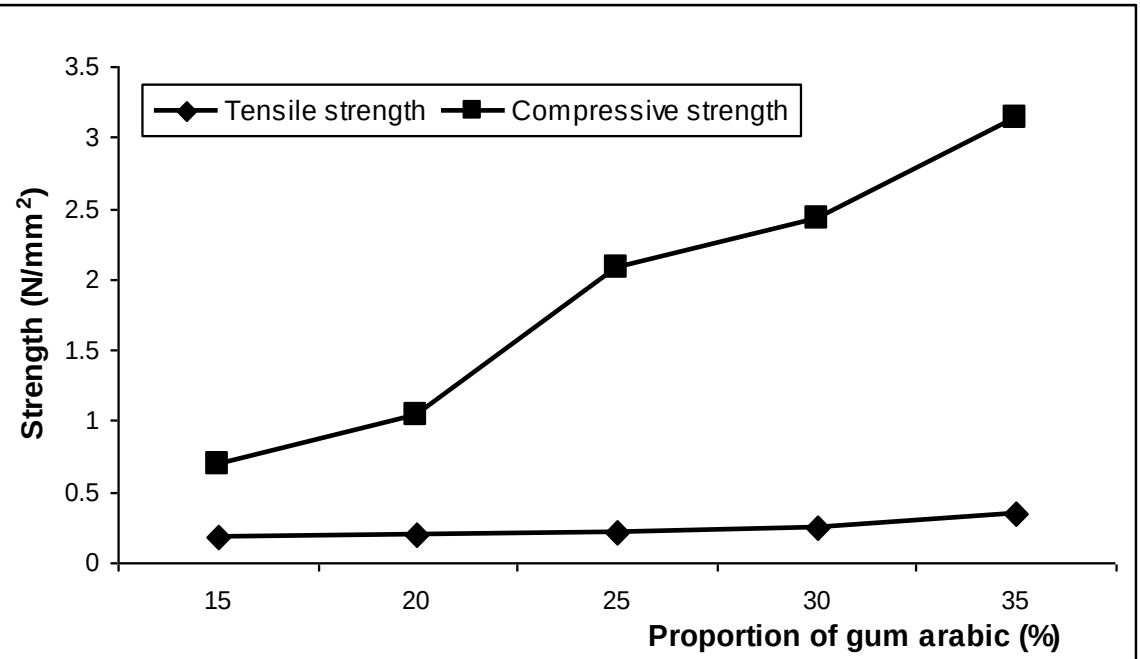


Fig.2: Tensile and Compressive strengths of RHP with different proportion of gum arabic binder

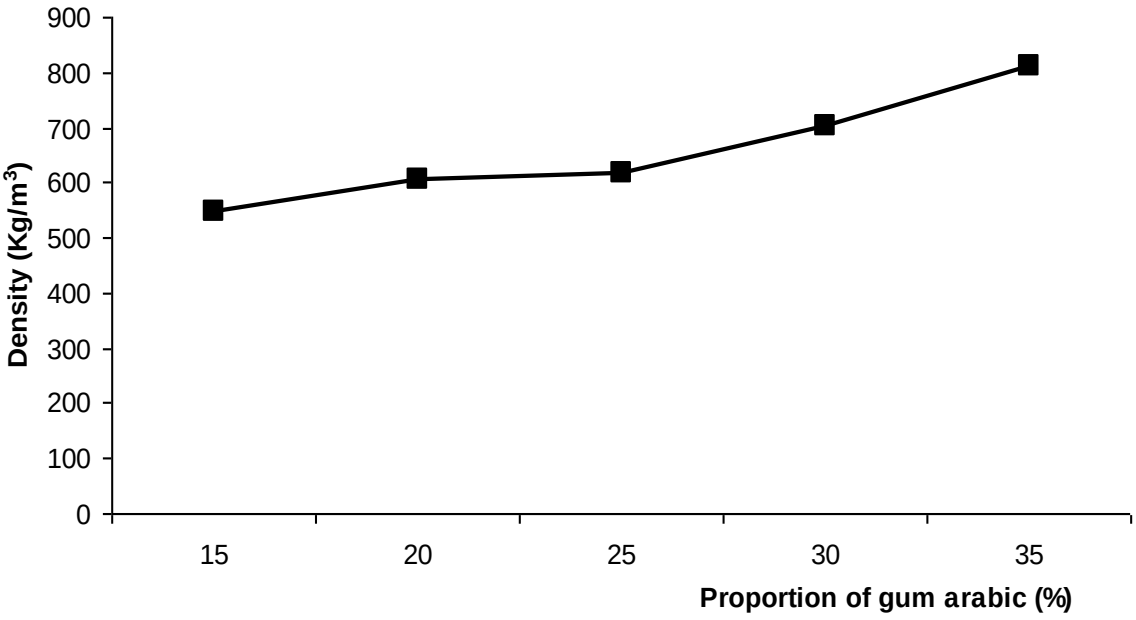


Fig.3: Density of RHP with different proportion of gum arabic binder

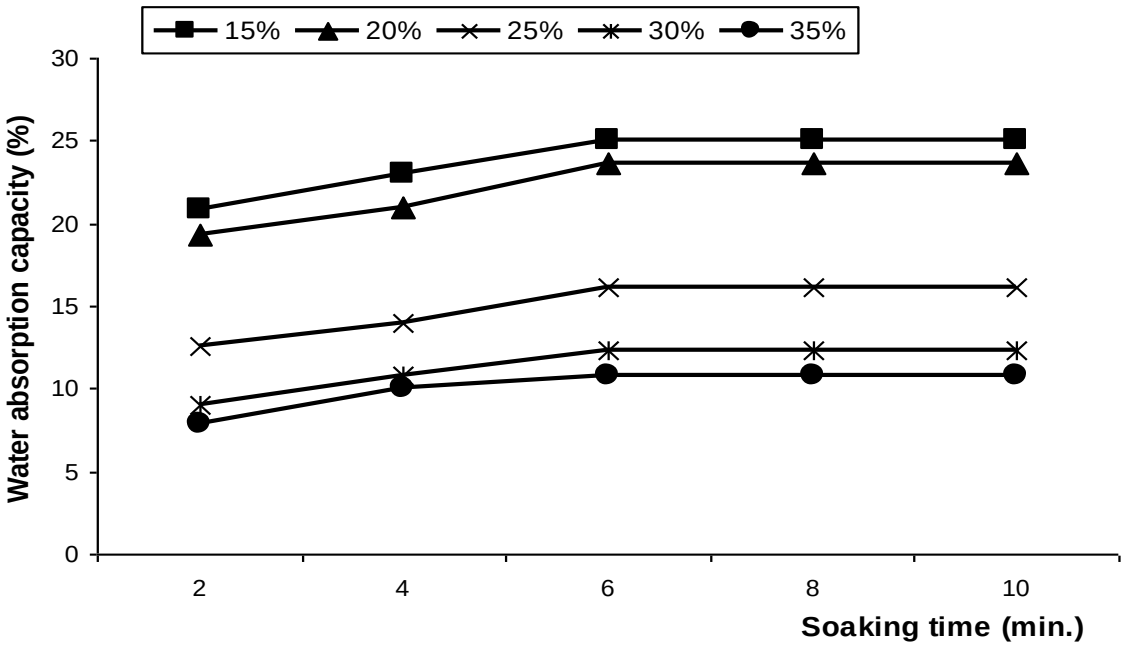


Fig.4: Water absorption trends for different proportions of gum arabic

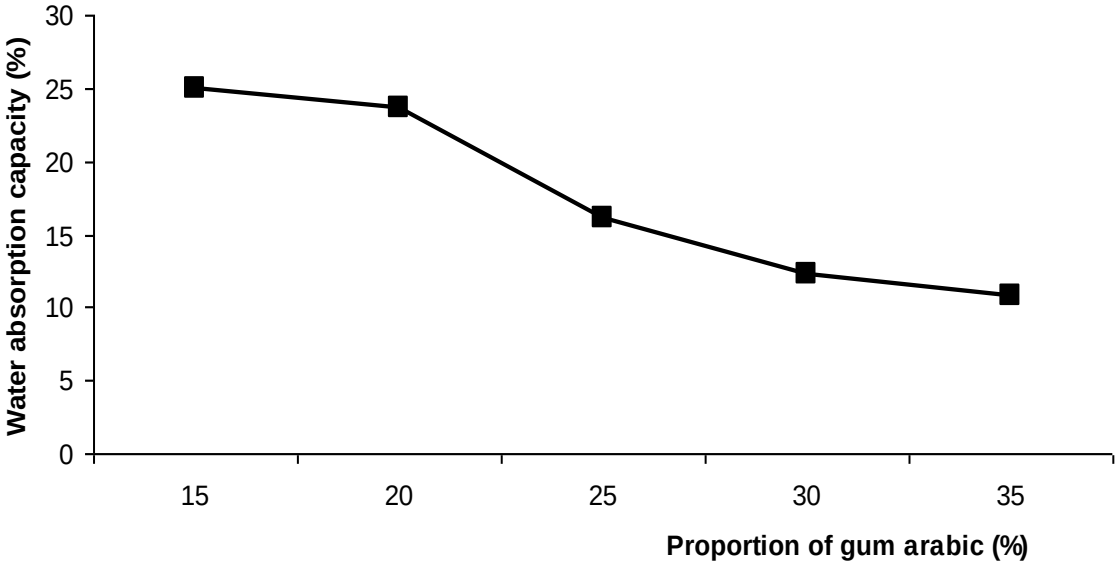


Fig.5: Water absorption capacity for different proportion of gum arabic

PHYSICAL AND CHEMICAL PROPERTIES OF GIDAN-KWANU TERMITE HILL

B. A. Alabadan and E. F. Omosekeji

Department of Agricultural and Bioresources Engineering
Federal University of Technology, Minna
topealabadan@yahoo.co.uk

ABSTRACT

The physical and chemical properties largely determines the suitability of the soil for its planned used and the management requirement to keep it most productive. This paper reports the physical and chemical characteristics of termite hill soil. The four soil samples used in this research were obtained from the GidanKwano campus of the Federal University of Technology, Minna. The determination of the physical and chemical properties of the soil samples were carried out in the Soil Science Laboratory of Federal University of Technology, Minna. The samples can be described as loam, sandy loam and sandy clay loam soils. The percentage total nitrogen ranged from 0.05% to 0.50%. The pH value ranges between 6.24 and 7.34 in water and between 4.93 and 5.82 in 0.01ml $CaCl_2$.The mean organic matter content of the soil expressed as organic carbon is generally low. The value ranges between 0.51 and 1.13 for organic carbon and between 0.91 and 1.94 for organic matter. It can therefore be concluded that the non-termite infested soil contains more nutrients and should be cultivated since more agricultural outputs can be derived on this soil. The possibilities of utilizing the termite infested soils for farm building construction purposes should be investigated.

Keywords: Soil, Termite hill, Physical properties, Chemical properties, Soil use

1.0 INTRODUCTION

Just as life is dependent on air and water, life is also dependent on soil. Soil provides the nutrients needed for plant growth, houses micro organisms responsible for decomposition of organic matter, and retains and purifies water. To a limited extent, the fertility of a soil determines its possible uses and to a larger extent, its yields. However, fertility level alone is not indicative medium. Fertility is more easily changed than soil physical properties (Capalan, 1992).

The termite hills are structures built by termite using soil from within the earth. These structures are used as shelter for the colony since termites are social insects. Termite hills can rise to a height of 5m tall and 7m in diameter (Ndaliman, 2004). The termite hill soil may include very diverse components such as solid minerals particles, water in various form and state and gaseous inclusions. In addition, termite soil may contain organic and mineral component which also affects the physical properties of soil.

Macro faunal activities in the soil are known to affect nutrient and organic matter of dynamic and structure of the soil. Such changes in soil particles have profound influences on the productivity of the ecosystem. Termites are the dominant macro faunal group in the tropical soils. Termites process considerable quantities of soil materials in their mound building activities. Such activities

might have potential effects on carbon sequestration, nutrient cycling, and soil texture. However, the role of termites in nutrient and organic matter dynamics, and textural changes in acid soils in Nigeria are not explored very well.

Termite hill properties such as refractoriness, porosity, permeability, thermal shock resistance, linear shrinkage, bulk density and specific gravity were improved with the addition of additives [Akinbode, (1996) and Ndaliman, (2004)].Termite activities significantly increase the soil texture (silt). From the obtained result it appears that the termite's activity improves the physical properties and fertility of the soil. It also reduces the activity of the acid soils.

Termite activities greatly improved water infiltration where termite tunnels in the soil allow rainwater to soak in deeply and help reduce runoff and consequent soil erosion. Ecologically, termites are important in nutrient recycling, habitat creation, soil formation and quality and, particularly the winged reproductives, as food for countless predators. Termites clear away leaf and woody litter and so reduce the severity of the annual bush fires in African savannas.

African termites will abandon their nest when their fertile queen dies and move on to another location. Often these abandoned mounds turn into thickets as vegetation flourish in the area due to the higher fertility of the soil. Thickets mean that lions, leopards and their young will in turn seek out the area. The termites definitely have their place in the balance of nature.

The utilization of such soils for crop production might reduce the cost of fertilizer inputs, thereby improving the economic returns to the tropical farmer. Exorbitant cost of improving the material (termite hill) and the high cost of working on the soil to gain its fertility have made soil analysis very difficult, hence farmers tend to shun such money demanding activity, to work a similar space for just subsistence agriculture.
Termite mounds are also of interest to humans, because prospectors that look for indicator minerals can usethem. By analyzing the soils in a termite mound, a prospector can learn more about the underlying soil and investigates whether it contains substances that may be useful.The objective of this study is to characterized textural and chemical properties of soils derived from termite mounds.

2.0 MATERIALS AND METHODS

2.1 Materials

The four soil samples used in this research were obtained from GidanKwano campus of the Federal University of Technology, Minna. Samples A, B, C and D were obtained at a distance of 100 meters from each other. The determination of the physical and chemical properties of the soil samples were carried out in the Soil Science Laboratory of Federal University of Technology, Minna.

2.2. Methods

2.2.1 Soil pH Determination

Apparatus

Glass-electrode pH meter

Reagents The reagents needed are 0.01m calcium chloride and Distilled water

Method / procedure

10 grammes of 2.0mm sieved soil weighed into a 500ml beaker in duplicate 25ml of water and 25ml of 0.01m $Cacl_2$ is added to the sample and stirred intermittently for the next 30 minutes. The soil suspension is allowed to settle the electronic pH meter is calibrated using buffer solution (pH4 and pH7). The pH of the sample is now determined using the pH meter.

2.2.2 Particle size analysis of soil

Apparatus

Thermometers for measuring temperature of the suspension, a 2mm sieve, Multimix machine with baffled "milkshake" cups, Glass cylinders of approximately one litre capacity for containing soil suspension during setting and Special hydrometers for measuring density of soil suspension.

Reagent The reagent needed is Sodium hexametaphosphate dispersing agents, 5%

Method/procedure:

Weigh 51.0g of air-dry soil which has passed through a 2.0mm sieve and transfer to a "milkshake" mix cup. (A 51.0g air-dry sample represents approximately 50.0g of oven dry soil). If the soil is estimated to contain 75% or more sand, 101.0g of soil are used. Add 50 cc of 5.0% sodium hexametaphosphate along with 100ml of distilled water. Mix with a stirring rod and let sample set for some minutes stir the soil suspension for 15 minutes with the multimix machine transfer the suspension from the cup to the glass cylinder. With the hydrometer in the suspension add distilled water to the lover blue line. The volume will then be 100ml.

Cover top of cylinder with the hand and invert several times until all soil is in suspension. Place cylinder on flat surface and note time. Immediately place soil hydrometer into suspension. Slide slowly into suspension until hydrometer is floating. The first reading on the hydrometer is taken at 40 seconds after the cylinder is set down. Remove hydrometer and record temperature of suspense with a thermometer.

After the first hydrometer reading let the suspension stand for 2 hours and take a second reading. Also take the temperature of the suspension. The first reading measures the percentage of silt and clay in suspension. The second reading indicates the percentage of clay in the suspension.

2.2.3 Determination of organic carbon and organic matter in soil (Walkey-Blackmethod)

Apparatus The apparatus needed is burettes, 50ml or 25ml

Reagents The reagents required are Potassium dichromate ($K_2Cr_2O_7$), H_2SO_4 conc., O-phosphoric acid (H_3PO_4), conc., O-phenantholine – ferrous complex, Barium diphenylamine wulfenite and Ferrous sulfate

Method / procedure

1. Take a representative sample and grind to pass through 2.00mm sieve.
2. Weigh out soil sample in duplicate and transfer to 250ml Erlenmeyer flask.

3. Pipette 10ml of $K_2Cr_2O_7$ solution accurately into each flask and soul gently disperse the soil.
4. Add rapidly 20ml conc. H_2SO_4 using an automatic pipette, directing the stream into the suspension. Immediately swirl the flask gently until soil and reagents are mixed, then swirl more vigorously for one minute. Rotate beaker again and allow the flask to stand on a sheet of asbestos for about 30 minutes.
5. Add 100ml of distilled water after standing for 30 minutes.
6. Add 3-4 drops of indicator and titrate with 0.5N ferrous sulfate solution. As this and point is approached, the solution takes on a greenish cast then changes to dark green. At this point, add the ferrous sulfate drop by drop until the colour changes sharply from blue to red (maroon colour) in reflected light against a white background.
7. Make the blank titration in the same manner, but without soil (steps, 3, 4, 5 and 6), to standardize the derogate.
8. Calculate the result according to the following formula;

   % organic carbon = $\frac{(A-B)\times 3\times M}{100}\times\frac{100}{W}$

9. % Organic C may also be expressed on oven-dry basic after correction for moisture content in air dry soil.

2.2.4 Determination of exchangeable Ca, Mg, K, Na and effective CEC in soil

Apparatus The apparatus include Centering, 100-ml volumetric flask and Atomic absorption spectrophotometer

Reagents The reagents include Acetic acid, glacial and NH_4OH, conc. and Ammonium acetate solution

Method / procedure

1. To 5g of sample, add 30ml of NH_4OAC and shake on mechanical shaker for 2 hours.
2. Centrifuge (2,000 rpm for 5-10 minutes). Carefully decant the clear supernatant into a 100ml volumetric flask.
3. Add another 30ml of NH_4OAC solution and shake for 30 minutes. Centrifuge and transfer the supernatant into the same volumetric flask.
4. Repeat step 3 and transfer the supernatant into the same volumetric flask.
5. Make up to mark with the NH_4OAC solution.
6. Determine K, N and Ca on a flame photometer. Determine Mg Ca on an atomic absorption spectrometer.
7. Effective CEC is equal to the sum of exchangeable bases (Ca, Mg, K and Na).

2.2.5 Determination of available P in soil (BRAY NO 1 Method)

Apparatus The apparatus used are Centrifuge, Mechanical shaker, 20ml test tube and B&L spectronic -20 elatrophotometer

Reagents The reagents needed are Ammonium fluoride, HCL, Extracting solution, Stannous chloride ($Sncl_2 2H_2O$) stock solution, Ammonium molybdate (NH_4) $MO_7O_{24}$and Stannous chloride ($Sncl_2$ $2H_2O$) dilute solution

Methods / procedure

1. Weigh 1g of air-dried soil sample (passed a 2mm sieve) into a 15ml centrifuge tube and add 7ml of the extracting solution
2. Shake for 1 minute on a mechanical shaker and centrifuge the suspension at 2,000rpm for 15 minutes.
3. Pipette 2ml of the clear supernatant into a 20ml test tube.
4. Add 5ml distilled water and 2ml of ammonium molybdate solution
5. Mix content properly and add 1ml of $Sncl_2$. $2H_2O$ dilute solution and mix again
6. After 5 minutes, but not later than 20 minutes, measure % transmittance on the electro photometer at 660mμ wave length.
7. Prepare standard curve within the range of O-1μg p/ml (ppm).
8. Plot the optical density (OD) of standard solution against the μg p/ml(or ppm) and calculate the content of extractable P in soil.

2.2.6 Determination of Nitrogen (N) in soil (Regular Macro-Kjeldahl Method)

Apparatus Mercury catalyst table

Reagents The reagents needed are Mixed boric acid-indicator solution, Sodium hydroxide, (NaOH), H_2SO_4, conc. AR, HCL (or H_2SO_4), 0.01N standard and K_2SO_4, AR

Method / procedure:

1. Weigh 5 to 10g of soil sample containing about 10mg of N (air dried, grind to pass 0.5mm sieve) in a dry 500ml, macro-KJELDAHL flask. Add 20ml of distilled water. Swirl the flask for a few minutes then allow to stand for 30 minutes.
2. Add 1 table of mercury catalyst and 10g of K_2SO_4. Then add 30ml of conc. H_2SO_4 through an automatic pipette
3. Heat the flask cautiously at low heat on the digestion stand. When the water has been removed and frothing has ceased, increase the heat until digest clears. Then boil the mixture for 5 hours. Regulate the heating during this boiling so that the H_2SO_4 condenses about halfway up the neck of the flask.
4. Allow the flask to cool and slowly add about 100ml of water to the flask.
5. Carefully transfer the digest into another clean macro-KJELDAHL flask (750m). Retain all sand particles in the original digestion flask because sand can cause sever bumping during keelhaul distillation. Wash the sand residue with 50ml of distilled water four times and transfer the liquid into the same flask.
6. Add 50ml H_3BO_3 indicator solution into a 500ml Erlenmeyer flask which is then placed under the condenser of the distillation apparatus. The end of the condenser is about 4cm above the surface of the H_3BO_3 solution.
7. Attach the 750ml KJELDAHL flask to the distillation apparatus. Flask opening the funnel stopcock. Commence distillation.
8. Keep condenser cool to minimize frothing and prevent suck-back.

9. Collect 150ml distillate and then stop distillation
10. Determine the NH_4.N in the distillate titrating with 0.01N standard HCL (or H_2SO_4) using of 26ml burette graduated at 0.1ml intervals. The colour change at the end point is from green to pink.
11. Calculate the % N content in soil.

3.0 RESULTS AND DISCUSSION

3.1 Results

The results of both physical and chemical properties of the soil samples collected from the project sites were analyzed below:

3.1.1 Physical properties of the soil

The results of composition analysis of various samples collected from the field are tabulated in Table 1.

Table 1 Textural classification of soil samples

S/N	Laboratory Number	Sample Description	Sand %	Silt %	Clay %	Textural class
1	SSD - 01	A	56.40	31.60	12.0	SCL
2	SSD – 02	B	52.80	43.60	13.6	SL
3	SSD – 03	C	46.40	41.60	12.0	L
4	SSD – 04	Control	54.40	31.60	14.0	SL

SCL – Sandy clay loam, SL – Sandy loam and L – Loam

3.1.2 Chemical properties of the soil

Total Nitrogen

The results obtained from the soil nitrogen analysis were presented in Table 2.

Table 2: Determination of total Nitrogen

Sample	Initial reading cm^3	Final reading cm^3	Value of acid cm^3	%N
A	10.3	10.8	0.5	0.50
B	10.0	10.3	0.3	0.28
C	10.9	11.1	0.2	0.14
Control	11.1	11.3	0.2	0.14
Blank	Blank	10.8	0.1	0.05

Soil pH

The pH values of the soil are as showed in Table 3.

Table 3: Soil pH

Sample	H_2O	0.01ml $CaCl_2$
A	6.46	5.82
B	7.34	5.22
C	6.35	4.93
Control	6.24	5.58

Organic Matter

Table 4 contained the organic matter content of the soil.

Table 4: Organic carbon and organic matter

Sample	Initial titre value (cm^3)	Final titre value (cm^3)	Volume used (cm^3)	Blank volume used (cm^3)	% O.C	% O.M
Blank	0.00	19.50	19.50			
A	0.00	16.50	16.00	3.50	0.525	0.90
B	0.00	15.00	15.00	4.00	0.670	1.16
C	15.00	28.00	13.00	6.00	0.970	1.67
Control	16.00	28.00	12.00	7.50	1.130	1.94

Exchangeable cations

The Exchangeable cations of the soil are shown in Table 5.

Table 5: Exchangeable cations

Sample	Na^+	K^+	Ca^{2+}	Mg^{2+}
A	1.11	0.94	4.16	3.84
B	1.05	0.91	3.20	1.76
C	0.98	0.84	1.60	0.20
Control	0.78	0.52	1.28	0.52

3.2 Discussion

3.2.1 Physical properties of the soil

The results of composition analysis of various samples collected from the field are tabulated in Table 1 when measured on the textural triangle. The percentage sand ranged from 46.40% for sample C to 56.40% for sample A while the silt ranges from 31.60% to 43.60% but those of clay ranged from 12.0% to 14.0%.

3.2.2 Physical properties of the soil

Total Nitrogen

The results obtained from the soil nitrogen analysis were presented in Table 2. The percentage total nitrogen ranged from 0.05% for the blank to 0.50% for sample A. The value of total nitrogen varies owing to the fact that different field have different soil nitrogen value.

Soil pH

The pH value as showed in Table 3 ranges between 6.24 and 7.34 in water, and between 4.93 and 5.82 in 0.01ml $CaCl_2$. The pH ion water indicates that the soil is more acid than alkaline though the acidity is weak. The source of acidity in the soil could be hydrogen ions from the permanent change on the soil mineral resources.

Organic Matter

The mean organic matter content of the soil expressed as organic carbon is generally low as shown in Table 4. The value ranges between 0.51 and 1.13 for organic carbon and between 0.91 and 1.94 for organic matter.

The general low content of organic matter could be contributed to several factors: which include low erratic rainfall which permits only sparse, grassy sometimes shrubby vegetation instead of dense and woody vegetation; high temperature that hasten liberalization and seasonal bush fire. Hence the organic matter is subjected to diminishing or reduction.

4.0 CONCLUSION

From the results obtained in this study, the organic matter and organic content in the non termite infested soil were higher in value when compared to those of the termite infested soil.

The pH value is also higher which enhances a very fast plant growth response in the soil than that of the termite infested soil. It can therefore be concluded that the non-termite infested soil contains more nutrients and should be cultivated since more agricultural outputs can be derived on this soil.

For higher output of crop to be realized, the non-termite infested soil should be cultivated and more capital should also be invested into cultivating it rather than waste resources on the non-termite infested soil which will not yield any financial gain.

The possibilities of utilizing the termite infested soils for farm building construction purposes should be investigated.

REFERENCES

Akinbode, F. O. (1996). An Investigation on the Properties of Termite Hill refractory Material for Furnace Lining, India Foundry Journal.

Capalan B. (1992): Organic gardening. Headline book Publ., London, UK.

Claire, K.E. (1977): Soil formation: An introduction to soil formation and plant growth p.30

Handlington G. and M. F. Schneider (1982): Correlation for soil properties. Pench press London (pp. 15 -16).

Mijinyawa, Y; E.B. Lucas and F.O. Adegunloye.(2007). Termite Mound Clay as Material for Grain Silo Construction. Agricultural Engineering International: the CIGREjournalManuscriptBC07002. Vol. IX.

Ndaliman, M. B. (2000). Effect of Certain Additives on Refractory Properties of Termite Hill for Furnace Lining, Proceeding of the 2nd Annual Engineering Conference, Federal University of Technology, Minna, 4th and 6th September, pp.139-144.

Skaife, S.H. (1956): Dwellers in darkness: An introduction of the study of termite. Longman and Co., London.

Wright P.H. and R. J. Paquette (1979): The nature and properties of soil. Macmillan Publishing Co. 8th Edition, (pp. 47- 49).

Yohanna, J. K;FulaniA.U. and F.D. Anda (2003). Prospect of Using Ant Hill Material for Control of Seepage in Earth Dams. Proceedings of the Nigerian Institute of Agricultural Engineers (25), 135-143.

OIL REMOVAL FROM PRODUCED WATER USING BANANA PEEL

I.M. Muhammad[1], U.A. El-Nafaty, and S. Abdulsalam

Chemical Engineering Programme, Abubakar Tafawa Balewa University,
PMB 0248, Bauchi-Nigeria

ABSTRACT

The oil content in produced water is posing health hazard to human and the environment in general and defies the aestheticism of the environment. Banana peel, an agricultural waste, usually thrown away indiscriminately, litters the environment. In this work, banana peel was used to remove oil component from produced water to reduce the use of expensive and hazardous treatment chemicals. The peel was characterized using FTIR, SEM, EDS, and surface area was measured by BET equipment. Standard method use employed for the production of biosorbent and removal of oil using batch process. The result of EDS spectroscopy revealed that the peel contained 88.52% C; 5.69% O; 2.19% Si; 2.80% K; and 0.80% Ca. Biosorption study with the peel showed that it can be used in the removal of oil (dissolved and dispersed oil) from produced water providing almost 100% removal at an equivalent dosage representing 267 mg banana peel/l produced water after 35 minutes equilibrium time and initial oil concentration as high as 194 mg/l. Several biosorption kinetic models were tested and it was discovered that banana peel biosorbent followed pseudo-second-order kinetic. Equilibrium isotherm studies on the generated data revealed that banana peel can best be described by Langmuir isotherm model.

Keywords: (Banana, Peel, Produced water, Biosorption, Kinetic models)
*Corresponding author: idrmis@yahoo.co.uk

1.0 Introduction

Treatment of oil spills remains a challenge to environmental scientists and technologists. Among all the existing techniques used for oil treatment, sorption is a popular technique because it is cheap, simple and effective (Banerjee *et al.*, 2006). Among the various sorbents used, banana peel appears to be the most attractive material in terms of cost, versatility and abundance. Oil removal by biological waste materials have been reported by several authors [Khaled *et al.*, (2011); Lin *et al.*, (2011); Othman *et al.*, (2008); Pasila, (2004); Suni *et al.*, (2004); Tania *et al.*, (2000); Vlaev *et al.*, (2011); Banerjee *et al*, (2006)]. During the 1970s increasing environment awareness and concern led to a search for new techniques to replace expensive/hazardous chemical treatment methods. These demands led to increasing interest in biosorption. The use of biosorbent has been proposed as an alternative, as it has proven affective on low concentrations.

The Biosorption process involve a solid phase (sorbent or biosorbent; biological material) and a liquid phase (solvent, normally water) containing a dissolved species to be sorbate (sorbate, metal ions). Due to higher affinity of the sorbent for the sorbate species, the later is attracted and removed by different mechanisms. The process continues till equilibrium is established between the amount of the solid-bound sorbate species and its portion remaining in the solution. The degree of sorbent affinity for the sorbent determines its distribution between the solid and liquid phases. The major advantage of biosorption over conventional treatment methods include low cost, high efficient, minimization of chemical and biological sludge, regeneration of biosorbent and possibility of metal recovery. Many authors used biological waste materials to treat different

pollutants ranging from metals to organic dye found in water. Among them included the biosorption of Cadmium, Copper, Nickel, and Zinc in aqueous solution on activated sludge by AjayKumar *et al.*, (2009). Nowicki *et al.*, (2010) investigated the sorption properties of walnut shell while Suni *et al.*, (2004) utilized cotton grass fibre as sorbent for oil spills. Kaewsam *et al.*, (2008) use banana peel as sorbent in the removal of cadmium ion from aqueous solution; Kaur, (2011) used sugarcane bagasse for the removal of erythrosim B and methylene blue from aqueous solution. Kinetics of Ni (II) was investigated using activated clay minerals by Mahmoud *et al.*, (2012). Hasana *et al.*, (2010) investigated the selenium remediation through up-flow-fixed-bed column.

In this study, banana peel was conditioned to provide good oil uptake from produced water. Isotherms equilibrium and kinetics studies on the data generated were made. Sorption of oil was made at different bio-waste loading rate, sorption time and room temperature at constant pH. Characterization of the bio-waste was made using FTIR, EDS-SEM and surface area measurement using nitrogen adsorption technique by BET method.

2.0 Materials

Banana peels were collected from Muda Lawal market, Bauchi Nigeria. Crude oil was obtained from Kaduna Refinery and Petrochemical Company, Kaduna-Nigeria. Tri-chloroethane was purchased from Chuzz Bond International, Jos-Nigeria. All chemicals/reagents were of analytical grade. Distilled water was produced in Gubi Dam Water Treatment Plant Laboratory, Bauchi-Nigeria. Oven was used to dry the sorbent materials (manufactured by Regaterm, Itaty). Separating funnels were used to extract out the oil from water and DR/2000 spectrophotometer (HACH, Colorado, U.S.A) was used to test the presence of oil in the extract. Hanna pH meter was used to determine the pH of the mixture. A JJ-4 Six couplet Digital electric mixer (Search Tech Instrument, England) was used for the sorption study. Laboratory mortar and pestle were used to convert the banana peel to powder and sieve was used to classify it into different sizes (212-63 microns). A Perkin Elmer Spectrum 100 FTIR spectrometer was used for the infra-red spectroscopic studies at wave numbers 4000-400 cm^{-1}. The X-ray diffractometry was done on a BRUKER AXS D8 Advance(Cu-Kα radiation $\lambda K\alpha_1$=1.5406Å) 40kV. The Hitachi X-650 Scanning Electron Microscope (Tungsten filament, EHT 20.00kV) and LEO 1450 Scanning Electron Microscope (Tungsten filament, EHT 20.00kV) were used for the SEM imaging. The chemical composition was determined using energy dispersive spectroscopy (EDS) and surface area and pore sizes were determined using TriStar 3000 V6.05 A BET equipment.

3.0 Method

3.1 Biosorbent Preparation

Banana peel was first washed with water several times and then sun-dried. The dried banana peel was ground to particle sizes between 2-3 mm and later treated with n-hexane to remove all coloured pigment in a reflux condenser. The n-hexane treated banana peel was later washed with distilled water and dried in an oven at 70^{o}C for 24 hours. This was further crushed and sieved through 212-63 microns sieve was then stored in air tight sealed plastic containers as RBP.

3.2 Characterization

The banana peel biosorbent (RBP) was characterized using FT-IR, SEM, and EDS. The spectrograms were presented in Figures 1, 2, and 3 respectively.

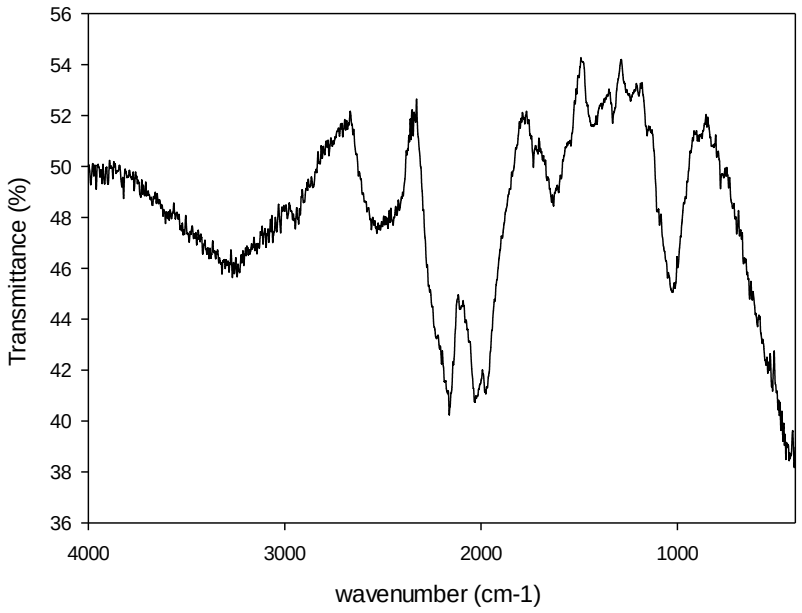


Figure 1: RBP FTIR

From the FTIR spectra in Figure 1 above, it can be seen that many peaks existed which is an indication of many functional groups. A shift at wave number 539 cm^{-1} was observed and was assigned to C-I stretching. The shift observed at 1035 $cm^{-1}$was assigned to Si-O-Si silicon stretching while the absorption at 1254 cm^{-1} was assigned to C-C stretch. The shift at 1338 cm^{-1} was assigned to phenol or tertiary alcohol OH bending. Shift at 1635 cm^{-1} was as a result of C=C stretching in which shift at 1988 cm^{-1} was due to aromatic in combination band. The last shift at 2167 cm^{-1} was assigned to C≡C stretching. These assignments are in agreement with Kamsonlian *et al*., (2011) but slightly differ from Kaewsam *et al.*, (2008) and Kumar *et al*., (2010).
Dissolved oil from the produced water (BETX) polarizes in water. The charged particles initiate a reaction by opening the double and triple bonds in the banana peel structure and exchange their ions to neutralize the charges. Where the pollutants do not dissociate in solution, adsorption is by affinity of the surface to bind with the pollutant through the porous structure of the sorbent material.

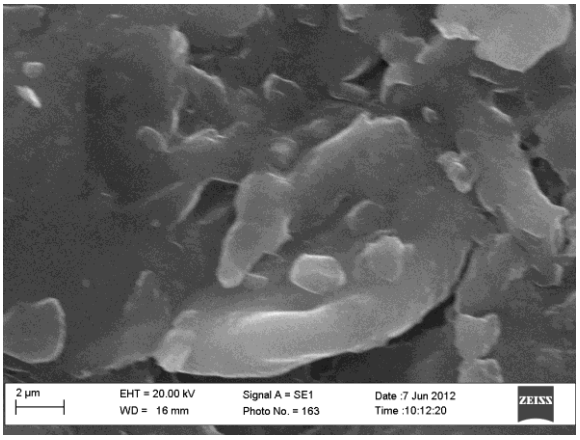


Figure 2: SEM of banana peel (RBP)

Figure 2 shows the SEM of RBP. However, it can be said to consist of layered materials clustered together in which the sorption may take place. Particles seen on the image were measured to have equivalent spherical diameter from 37.357-179.619x 10^{-6} m and cross sectional area of $62*10^{-12}$-$206*10^{-12}$ m^2.

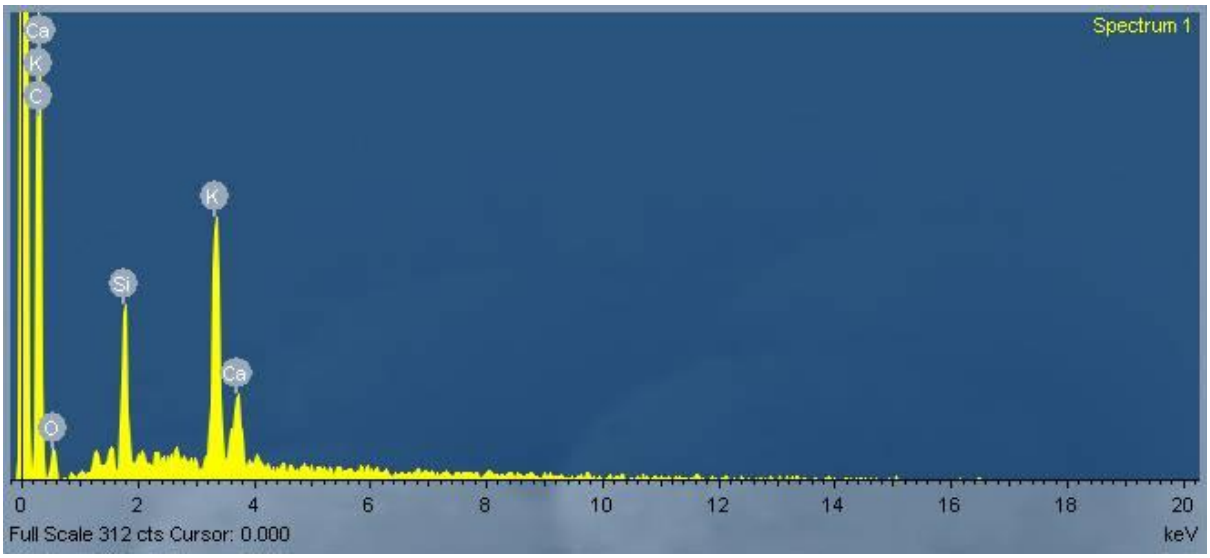


Figure 3: EDS of banana peel (RBP)

Table 1: Elemental analysis of RBP

Element	Weight, g	Atomic, %
C	4.65	88.52
O	0.40	5.69
Si	0.27	2.19
K	0.48	2.80
Ca	0.14	0.80
Totals	5.93	100

The high carbon content in the sample was an indication that it consist of carbonaceous materials. However, not all the carbon content comes from the material originally but majority comes from the carbon film coated during analyzing the sample in electron dispersion microscope.

The use of peels and other bio-waste materials not only would provide less costly adsorbent or synthetic ion exchangers but is also easily available and save the environment. Banana peel has an average particle size of 0.89 nm as reported by Kamsonlian *et al.*, (2011) and a BET surface area of 1.856 m^2/g. The surface area of RBP by BET and Langmuir methods were found to be 0.1135 and 0.1307 m^2/g respectively. Its average pore size was determined to be 58.33421 nm while its pore volume determined to be 0.001655 cm^3/g. However, the surface area did not agree with what was reported by Kamsonlian *et al.*, 2011.

3.3 Batch adsorption experiments

The experiments were carried out by taking 300 mL of 194 mg/l produced water and different quantity of RBP in a 600 ml beaker. The contents were then agitated at 700 rpm for 30 minutes using mechanical shaker at room temperature. The biosorbent and sorbate were separated by 63 micron sieve. Studies on the effects of agitation time, and biosorbent dose were carried out by

using known amounts of biosorbents of particle size 212-63 microns. Oil solutions (300 mL) with different amounts of biosorbents were taken to study the effect of adsorbent dosage on the removal of oil. The biosorption experiments were carried out at room temperatures.

3.3.1 Sorption Experiment

The laboratory synthesized produced water (oil-in-water mixture) was prepared by mixing crude oil with distilled water and its pH was measured. The pH was kept constant during the experiment. The already prepared oil-water mixture was treated differently with various quantities of RBP for a period of 30 minutes and a stirring speed of 700 rpm. At the end of the treatment, RBP was removed from the oil/water mixture by passing through 63microns sieve and the residual oil in the water was determined using 1-1-1-tri-chloroethane as solvent. The extract was analyzed for oil content using HACH DR/2000 spectrophotometer at a wavelength of 450 nm. The test was repeated until optimum loading point was identified. The results are presented in Table 2. With the optimum loading kept constant, the time was varied to determine the optimum time of the sorption study and the results are presented in Table 3.

3.4 Adsorption isotherm

One can readily deduce that at low sorbate concentrations it effectively reduces a linear isotherm and thus follows Henry's law. Alternatively, at high sorbate concentrations, it predicts a constant – monolayer – sorption capacity.Among several models that have been published in the literature to describe experimental data of adsorption isotherms Langmuir and Freundlich are the most frequently used models. Equilibrium isotherm equations are used to describe experimental sorption data. The equation parameters and the underlying thermodynamic assumptions of these equilibrium models often provide some insight into both the sorption mechanism and the surface properties and affinity of the sorbent. The symbols and coefficients used in the equations are defined.

3.4.1. The Freundlich Isotherm

In 1906, Freundlich presented the earliest known sorption isotherm equation (Freundlich, 1906). This empirical model can be applied to non-ideal sorption on heterogeneous surfaces as well as multilayer sorption and is expressed by the following equation (HO, *et al.*, 2001):

$$q_e = a_f C_e^{bF} \quad (1)$$

Where, a_FFreundlich isotherm constant; *Ce* Solution phase oil concentration at equilibrium, mg dm^{-3};

The Freundlich isotherm has been derived by assuming an exponentially decaying sorption site energy distribution. It is often criticised for lacking a fundamental thermodynamic basis since it does not reduce to Henry's law at low concentrations. The linearized Freundlich equation can be used (equation 2):

$$lnq_e = lna_F + b_F lnC_e \quad (2)$$

A plot of lnq_e vs lnC_e is a straight line with slope b_F and interceptlna_F. This is shown in Figure 4.

3.4.2. The Langmuir Isotherm

In 1916 Langmuir developed a theoretical equilibrium isotherm relating the amount of gas sorbed on a surface to the pressure of the gas (Langmuir, 1916). The Langmuir model is probably the best known and most widely applied sorption isotherm. It has produced good agreement with a wide variety of experimental data and may be represented as in equation 3 (Ho *et al.*, 2001): The Langmuir adsorption isotherm assumes that adsorption takes place at specific homogeneous sites within the adsorbent, and it has been used successfully for many adsorption processes of monolayer adsorption. The linearized Langmuir can be used (equation 4):

$$q_e = \frac{k_L C_e}{1+a_L C_e} \qquad 3$$

$$\frac{C_e}{q_e} = \frac{1}{k_L} + \frac{aL}{k_L} C_e \qquad 4$$

$$\frac{1}{q_e} = \frac{1}{q_0} + \frac{1}{k_L\, c_e q_0} \qquad 5$$

Wherein C_e is the equilibrium concentration of the sorbate (milligrams per litre), q_e is the amount of sorbate per unit mass of biosorbent (milligrams per gram), $q_0 = k_L$ and $b = \frac{aL}{kL}$ are Langmuir constants related to biosorption capacity and rate of biosorption respectively. When $\frac{1}{qe}$ was plotted against $\frac{1}{Ce}$ for RBP using equation 5, a straight line with slope $\frac{1}{qokL}$ was obtained, as shown in Figure 5.

The essential characteristics of the Langmuir isotherm can be expressed in terms of a dimensionless equilibrium parameter, R_L which is defined by.

$$R_L = \frac{1}{1+_{bCo}} \qquad 6$$

Where, C_o is the highest initial solute concentration, 'b' the Langmuir's adsorption constant (L/mg). The value of R_L indicated the type of the isotherm to be either unfavorable (R_L>1), linear (R_L =1), favorable (0< R_L<1) or irreversible (R_L = 0).

4.0 RESULTS AND DISCUSSION

4.1 Results

Tables 2 and 3 present the results obtained on biosorption of oil from water using RBP.

Table 2: Effect of RBP loading rate on oil removal from produced water

Dosage (mg)	Oil left (mg/L)	Oil removed (mg/L)	% Removal
0	194	0	0
20	6.40	187.60	96.70
30	2.13	191,87	98.90
65	2.13	191.87	98.90
80	0.00	194.00	100.00
92.5	0.00	194.00	100.00

Table 3: Effect of contact time on the biosorption of oil from produced water

Time(minutes)	C_e Oil left(mg/L)	Oil removed (mg/L)	% Removal
0	194	0	0
5	85.27	108.73	56.04
10	83.96	130.04	67.03
15	57.56	136.44	70.33
20	56.69	134.31	69.23
25	38.37	155.63	80.22
30	2.13	191.87	98.90
35	0.00	194.00	100.00
40	0.00	194.00	100.00

4.2 Discussion

The linearized form of Freundlich and Langmuir isotherms (equations 2 and 5) were used on the generated data. Figures 4 and 5 resulted with generated data from Table 4.

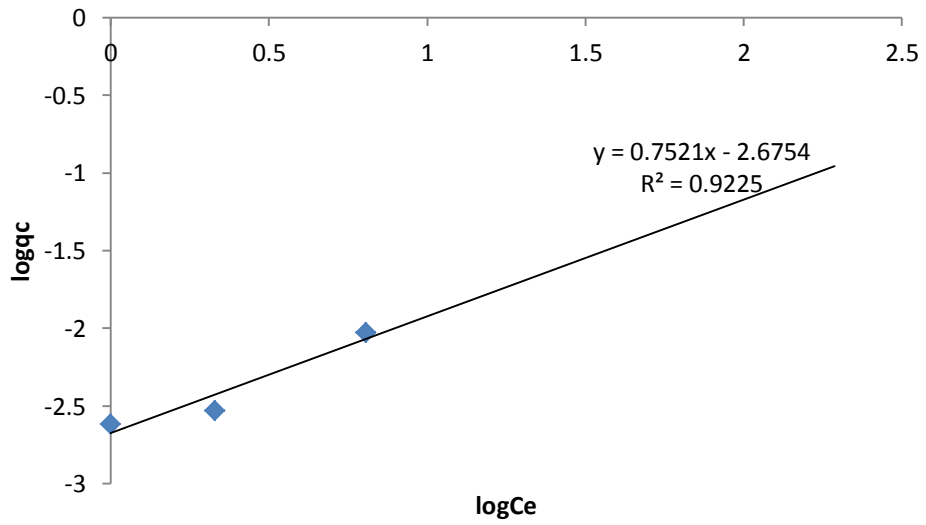


Figure 4: Freundlich Isotherm of RBP

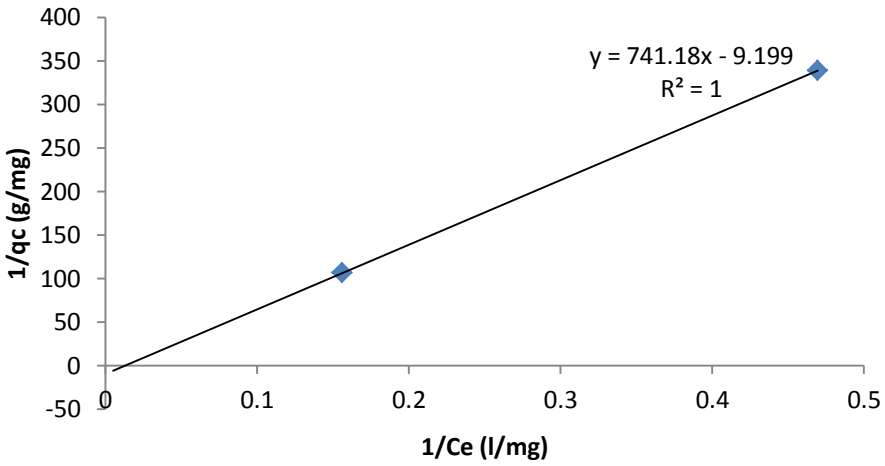


Figure 5: Langmuir Isotherm of RBP

From figures 4 and 5, it can be seen that the R^2 value for the charts are high. The biosorption can be described by all the isotherms but can best be described by the Langmuir isotherm. This indicate that sorption by this waste is mono-layer as suggested by Langmuir. The constants evaluated can be seen in Table 4.

Table 4: Evaluated constants from Langmuir and Freundlich isotherms by RBP

Isotherm	R^2	k_L	q_o	a_F	b_F	R_L
Langmuir	1.0000	-0.0124	-0.109	-	-	0.7923
Freundlich	0.9225	-	-	0.0609	0.7521	-

R_L was evaluated from figure 5 and the value obtained was 0.7923. The value falls within $0<R_L<1$ and hence favorable adsorption. The adsorption favored mono-layer as it agreed well with Langmuir isotherm $R^2=1$.

4.2.1 Kinetic studies

Many kinetic models have been proposed to elucidate the mechanism of solute adsorption. These kinetic models are useful for the design and optimization of effluent treatment process.
In order to investigate the mechanism of oil biosorption by RBP, the following five (5) kinetic models were considered.

Pre-equilibrium kinetic profiles were characterized in order to determine the rate limiting steps involved in the process of biosorption of oil onto RBP. The first order (Eq. 7), Lagergren pseudo-first order (Eq. 8) and pseudo-second order (Eq. 9) kinetic models were applied in the biosorption of nickel on spent activated clay (Mahmoud et al., 2012), reactive black 5 dye by Aspergillus foetidus (Patel and Suresh, 2008), biosorption of Acid Red 57 by dried *Cephalosporium aphidicola* cells (Kiran et al., 2006).

$$\frac{1}{q_t} = \frac{1}{q_e} + \frac{k_1}{q_e t} \qquad 7$$

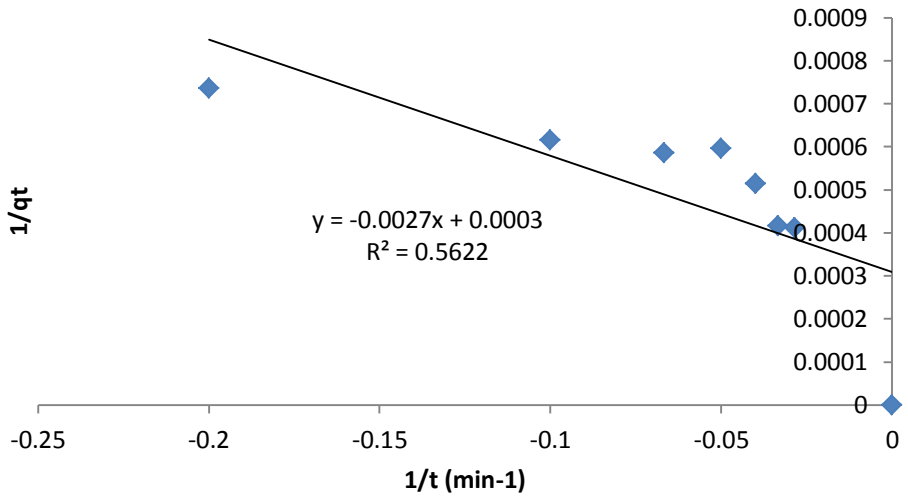


Figure 6: First order kinetic model of RBP

4.2.2 Pseudo first order kinetic model

The integrated linear form of pseudo first order kinetic model the model proposed by Lagergren is

$$\ln(q_e - q_t) = lnq_e - kt \qquad 8$$

Where, q_e is the amount of dye adsorbed at equilibrium (mg/g), q_t is the amount of oil adsorbed at time t (mg/g), k_1 is the first order rate constant (min^{-1}) and t is the time (min). Hence, a linear trace is expected between the two parameters log (q_e - q_t) and t, provided the biosorption follows first order kinetics. The values of k_1 and q_e can be determined from the slope and intercept. Even though q_e and the R^2 value suggest that the biosorption data badly fitted to pseudo first order kinetics. Hence, the biosorption of oil onto RBP may not follow the pseudo first order rate expression.

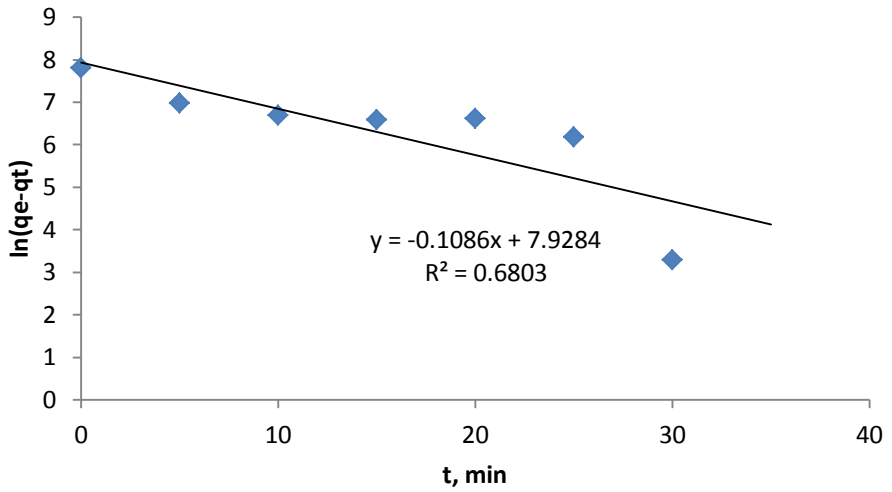


Figure 7: Pseudo-first-ordre Kinetic Model of RPB

4.2.3 Second order and Pseudo second – order kinetics

The biosorption may also be described by a second order or pseudo second order kinetic model .The linearized form of the second order and pseudo second order models are:

$$\frac{1}{C_e} = k_2 t + \frac{1}{C_0} \qquad 9$$

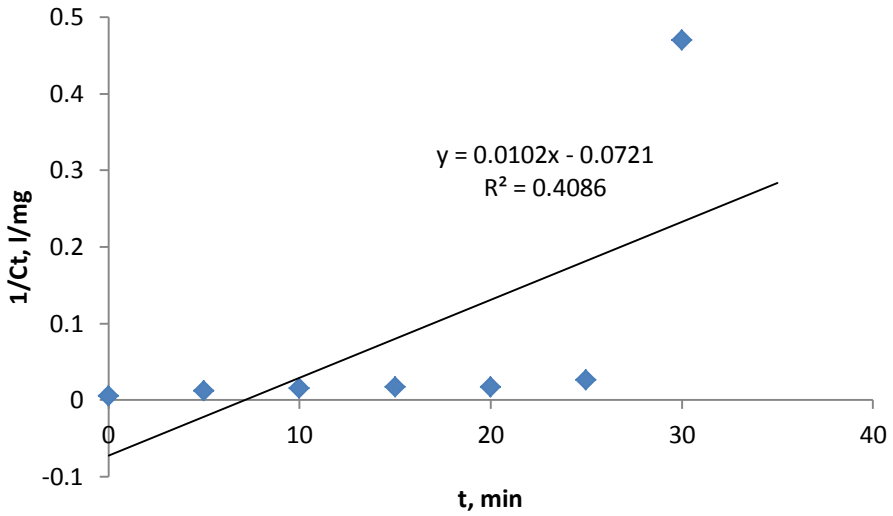


Figure 8: Second Order Kinetic Model of RBP

$$\frac{t}{q_t} = \frac{1}{k_2 q_e^2} + \frac{1}{q_e} t \qquad 10$$

Where, k_2 is the second order rate constant (g/mg min). A plot of $1/q_e$ vs t and t/q_t vs t should be linear if the adsorption follows second order or pseudo-second order. q_e and k_2 can be calculated from the slopes and intercepts of the plots.

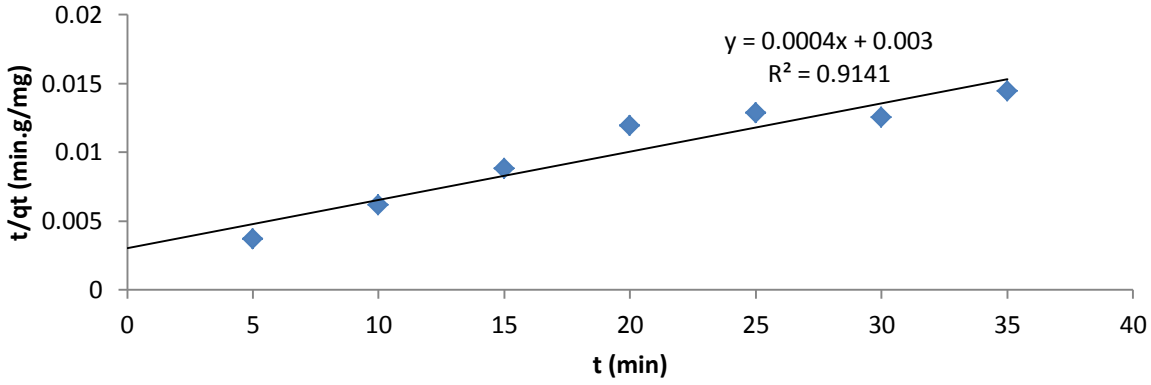


Figure 8: Pseudo-second-order Kinetic Model of RBP

4.2.4 Elovich model

The Elovich equation is mainly applicable for chemisorption process. The equation is often valid for systems in which the adsorbing surface is heterogeneous. The Elovich model is generally expressed as

$$q_t = \frac{1}{b}\ln(ab) + \frac{1}{b}lnt \qquad 11$$

Where, a is the initial biosorption rate (mg/g min) and b is related to the extent of surface coverage and the activation energy for chemisorption (g/mg). A plot of q_t vs lnt gives a straight line with a slope of l/b and an intercept of l/bln(ab) with good correlation coefficients.

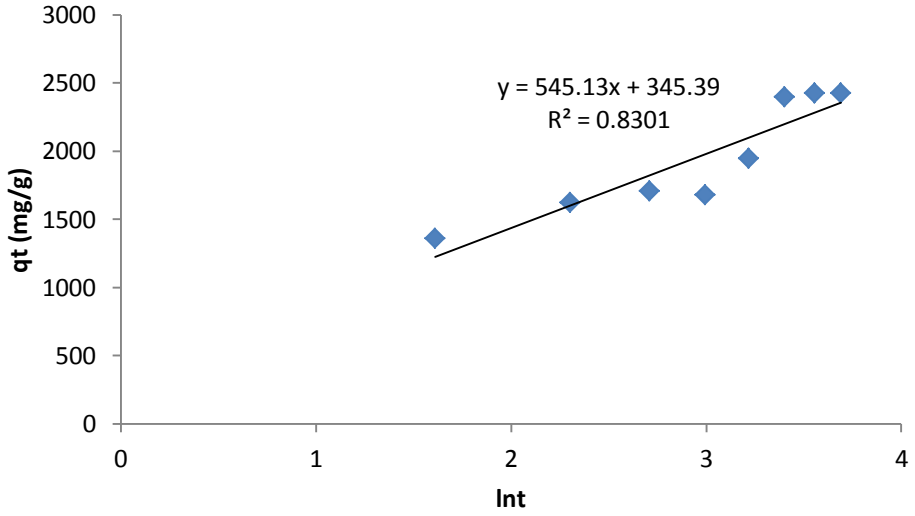


Figure 9: Elovich Kinetic Model of RBP

From Fig. 6-9, it can be deduced that oil sorption from produced water using RBP followed pseudo-second-order kinetics. Comparison of the tested kinetics can be seen in Table 6. The various kinetics constants were evaluated and included.

Table 5: Comparison of the biosorption kinetics and evaluated constants

Kinetics	R^2	Intercept	Slope	Rate constant (k)	q_e	C_o	a	b
First-order	0.5622	0.0003	-0.1027	-340.67	3333.33	-	-	-
Pseudo-first-order	0.6803	7.9284	0.1086	0.1086	2774.98			
Second-order	0.4086	-0.6721	0.0102	0.0102	-	i.4879	-	-
Pseudo-second-order	0.9141	0.003	0.0004	5.333E-3	2500	-	-	-
Elovich	0.8301	345.39	545.13	-	-	-	1046.87	0.0018

5.0 CONCLUSION

RBP was characterized using FTIR, SEM, EDS, and BET equipment. The characterization using FTIR revealed the functional groups present on the RBP while SEM revealed the surface morphology of the sorbent. EDS revealed the elemental composition and discovered to contain carbon, oxygen, silicone, potassium, and calcium as can be seen in Table 1. Surface area of the RBP was measured using nitrogen adsorption by BET method and was found to be 1.856 m^2/g with average pore size of 58.3342 nm. Biosorption study with the peel showed that it can be used in the removal of oil (dissolved and dispersed oil) from produced water providing almost 100% removal at an equivalent dosage representing 267 mg banana peel/l produced water after 35 minutes exposure and initial oil concentration as high as 194 mg/l. Several biosorption kinetic models were tested and it was discovered that RBP biosorbent followed pseudo-second-order kinetic. Langmuir and Freundlich isotherms were tested with the data and was discovered that the sorption can best be described by Langmuir isotherm indicating mono-layer adsorption of oil on the RBP surface.

6.0 Acknowledgement

The authors acknowledged the financial support of the First Bank of Nigeria (Plc) through the First Bank Professorial Chair in Chemical Engineering Programme, Abubakar Tafawa Balewa University, Bauchi-Nigeria.

REFERENCE

AjayKumar, A.V., Darwish, N.A. and Hilal, N. (2009) 'Study of Various Parameters in the Biosorption of Heavy Metals on Activated Sludge', *World Applied Sciences Journal*, vol. 5, no. special, pp. 32-40.

Angelovaa, D., Uzunovb, I., Uzunovaa, S., Gigovac, A. and Minchev, L. (2011) 'Kinetics of oil and oil products adsorption by carbonized rice husks', *Chemical Engineering Journal, 172*, pp. 306-311.

Arunachalam, R. and and Annadurai, G. (2011) 'Nano porous adsorbent from fruit peel waste for decolorization studies', *Research Journal of Environmental Sciences*, vol. 5, no. 4, pp. 366-376.

Banerjee, S.S., Joshi, M.V. and Jayaram, R.V. (2006) 'Treatment of oil spill by sorption technique using fatty acid grafted sawdust', *Chemosphere*, vol. 64, pp. 1026-1031.

Bhatnagar, A. and Sillanpää, M. (2010) 'Utilization of agro-industrial and municipal waste materials as potential adsorbents for water treatment—A review', *Chemical Engineering Journal*, vol. 157, p. 277–296.

Bhatti, Y.S.a.H.N. (2011) 'Adsorptive removal of direct textile dyes by low cost agricultural waste: Application of factorial design analysis', *Chemical Engineering Journal 167 (2011) 35–41*, vol. 167, pp. 35-41.

Calero, M., Hernaiz, F., Blazquez, G., Martin-Lara, M.A. and and Tenorio, G. ((2009)) 'Biosorption kinetics of Cd(II), Cr(III) and Pb(II) in aqueous solution by olive stone', *Brazilian Journal of Chemical Engineering*, vol. 26, no. 02, pp. 265-273.

Coates, J. (2000) 'Interpretation of Infrared, A practical approach', in Meyers, R.A. (ed.) *Encyclopedia of Analytical Chemistry*, Chichester: John Wiley & sons Ltd.

Gao, J.-F., Zhang, Q., Wang, J.-H., Wu, X.-L., Wang, S.-Y. and Peng, Y.-Z. (2011) 'Contributions of functional groups and extracellular polymeric substances on the biosorption of dyes by aerobic granules', *Bioresource Technology*, vol. 805-813, p. 102.

Hasana, S.H., Ranjana, D. and Talat, M. (2010) 'Agro-industrial waste 'wheat bran' for the biosorptive remediation of selenium through continuous up-flow fixed-bed column', *Journal of Hazardous Materials*, vol. 181, pp. 1134-1142.

Ho, Y.S., Porter, J.F. and Mckay, A.G. (2001) *equilibrium isotherm studies for the sorption of divalent metal ions onto peat: copper, nickel and lead single component systems*, september, [Online] [21 june 2012].

Kaewsam, P., Saikaew, W. and and Wongcharee, S. (2008) 'Dried biosorbent derived from banana peel: A potential biosorbent for removal of Cadmium ions from aqueous solution', The 18th Chemical Engineering & applied chemistry conference, Pattaya, Thailand, 20-27.

Kamsonlian, S., Suresh, S., Majumder, C.B. and and Chund, S. (2011) 'Characterization of orange and banana peels: Biosorption mechanisms', *International Journal of Science Technology Management*, vol. 2, no. 4, pp. 1-7.

Kaur, P.S.a.H. (2011) 'Sugarcane bagasse for the removal of erythrosin B and methylene blue from aqueous waste', *Appl Water Sci (2011) 1:135–145*, vol. 1, pp. 135-145.

Khaled, O., Mona, E.-S. and Y., E.-K.M. (2011) 'Treatment of oil–water emulsions by adsorption onto activated carbon, bentonite and deposited carbon', *Egyptian Journal of Petroleum*, vol. 20, pp. 9-15.

Kiran, I., Akar, T., Ozcan, A.S., Ozcan, A. and Tunali, S. (2006) 'Biosorption kinetics and isotherm studies of Acid Red 57 by dried Cephalosporium aphidicola cells from aqueous solutions', *Biochemical Engineering Journal*, vol. 31, july, p. 197–203.

Kumar, G.V., Ramalingam, P., Kim, M.J., Yoo, C.K. and and Kumar, M.D. (2010) 'Removal of acid dye (violet 54) and adsorption kinetics model of spp. waste: A lowcost natural sorbent material', *Korean Journal of Chemical Engineering*, vol. 27, no. 5, pp. 1469-1475.

Lim, T.-T. and Huang, X. (2007) 'Evaluation of kapok (Ceiba pentandra (L.) Gaertn.) as a natural', *Chemosphere*, pp. 955-963.

Lin, J., Shang, Y., Ding, B., Yang, J., Yu, J. and Al-Deyab, S.S. (2011) 'Nanoporous polystyrene fibers for oil spill cleanup', *Marine Pollution Bulletin*, pp. 1-6.

Lin, J., Shang, Y., Ding, B., Yang, J., Yu, J. and Al-Deyab, S.S. (2011) 'Nanoporous polystyrene fibers for oil spill cleanup', *Marine Pollution Bulletin*, pp. 1-6.

Liu, J., Wu, Q. and and Ding, Y. (2005) 'Assembling synthesis of BaSO4 biometric nano-superstructures through eggshell membrane template', *chemical resource Chinese U.*, vol. 21, no. 2, pp. 243-245.

Mahmoud, N.S., Atwa, S.T., Sakr, A.K. and Geleel, M.A. (2012) 'Kinetic and Thermodynamic Study of the Adsorption of Ni (II) using Spent Activated Clay Mineral', *New York Science Journal*, vol. 5, no. 2, pp. 62-68.

Mohammed, I.E., Gihan, F.M. and and Yuh-Shan, H. (2010) 'On the use of linearized second order kinetics equation for modelling adsorption systems', *Desalination*, vol. 257, pp. 93-101.

Muhammad, I., Quratulain, S., Sajjad, A., Muhammad, G.S. and Shahjahan, B..a.M.N. (2011) 'FTIR & SEM analysis of thermo-chemical fractioned sugarcane bagasse', *Turkish Journal of Biochemistry*, vol. 36, no. 4, pp. 322-328.

Nowicki, P., Pietrzak, R. and Wachowska, H. (2010) 'Sorption properties of active carbons obtained from walnut shells by chemical and physical activation', *Catalysis Today 150 (2010) 107–114*, vol. 150, pp. 107-114.

Othman, M.R., Akil, H.M. and and Kim, J. ((2008)) 'carbonaceous Hibiscus cannabinus L. (kenaf) for treatment of oil-and-metal-contaminated water', *Bio-Chemical Engineering Journal*, vol. 41, pp. 171-174.

Özcana, A.S., Tunalib, S., Akarb, T. and Özcana, A. (2009) 'Biosorption of lead(II) ions onto waste biomass of Phaseolus vulgaris L.: estimation of the equilibrium, kinetic and thermodynamic parameters', *Desalination 244 (2009) 188–198*, vol. 244, June, pp. 188-198.

Parab, H., Sudersanan, M., Shenoy, N., Pathare, T. and Vaze, B. (2009) 'Use of Agro-Industrial Wastes for Removal of Basic Dyes from Aqueous Solutions', *Clean 2009, 37 (12), 963 – 969*, vol. 37, no. 12, pp. 963-969.

Pasila, A. (2004) 'A biological oil adsorption filter', *Marine Pollution Bulletin*, vol. 49, pp. 1006-1-12.

Patel, R. and Suresh, S. (2008) 'Kinetic and equilibrium studies on the biosorption of reactive black 5 dye by Aspergillus foetidus', *Bioresource Technology*, vol. 99, december, p. 51–58.

Paulo, H.F.P., Herman, C.J.V., Maria, O.H.C., Daniella, R.M., Sandra, M.D.L. and and Maria, L.C.P. (2011) 'Sugarcane bagasse pulping and bleaching: Thermal and chemical characterization', *Bioresources*, vol. 6, no. 3, pp. 2471-2482.

Qiu, H., Lv, L., Pan, B., Zhang, Q., Zhang, W. and and Zhang, Q.X. (2009) 'critical review in adsorption kinetic models', *Journal of Zhejiang University Science A*, vol. 10, no. 5, pp. 716-724.

Sitea, A.D. (2001) 'Factors Affecting Sorption of Organic Compounds in Natural Sorbent/Water Systems and Sorption Coefficients for Selected Pollutants. A Review', *J. Phys. Chem. Ref. Data, Vol. 30, No. 1*, october, pp. 187-439.

Soliman, E.M., Ahmed, S.A. and Fadl, A.A. (2011) 'Reactivity of sugar cane bagasse as a natural solid phase extractor for selective removal of Fe(III) and heavy-metal ions from natural water samples', *Arabian Journal of Chemistry (2011) 4, 63–70*, vol. 4, pp. 63-70.

Suni, S., Kosunen, A.-L., Hautala, M., Pasila, A. and Romantschuk, M. (2004) 'Use of a by-product of peat excavation, cotton grass fibre, as a sorbent for oil-spills', *Marine Pollution Bulletin*, vol. 49, pp. 916-921.

Suni, S., Kosunen, A.L., Hautala, M., Pasila, A. and Romantschuk, M. (2004) 'Use of a by-product of peat excavation, cotton grass fibre, as a sorbent for oil-spills', *Marine Pollution Bulletin 49 916–921*, vol. 49, pp. 916-921.

T a n i a, Hubert Ribeiro., Ross, W. Smith. and Jorge Rubio (2000) 'Sorption of Oils by the Nonliving Biomass of a Salvinia sp.', *Environ. Sci. Technol.*, vol. 34, pp. 5201-5205.

Venkateswaran, P. and Parimaladevi, V. (2011) 'Kinetics, Thermodynamics and Isotherm Modeling of adsorption of triphenylmethane dyes (methyl violet, malachite green and magenta II) on to fruit waste', *Journal of Applied Technology in Environmental Sanitation*, vol. 1, no. Numb e r 3, october, pp. 2 7 3 - 2 8 3.

Vlaev, L., Petkov, P., Dimitrov, A. and Genieva, S. (2011) 'Cleanup of water polluted with crude oil or diesel fuel using rice husks ash', *Journal of the Taiwan Institute of Chemical Engineers*, vol. 42, June, p. 957–964.

SECTION V

EMERGING TECHNOLOGIES IN AGRICULTURAL ENGINEERING

BIOMASS BRIQUETTING AND ITS PERSPECTIVES IN NIGERIA

[1]Obi, O. F., Akubuo, C. O. and [2]Okonkwo, W. I.
Agricultural and Bioresources Engineering Department, University of Nigeria, Nsukka
[1]francis.obi@unn.edu.ng, [2]ifeanyiwilfred@yahoo.com

ABSTRACT

Biomass is naturally abundant and presents a renewable energy opportunity that could serves as an alternative to fossil fuel. However, biomass is generally considered to be a waste in Nigeria but is produced in abundance in rural communities. The effective utilization of these materials offers many advantages among which is being a renewable and sustainable energy feedstock for the production of solid fuel. One method of achieving this is through biomass briquetting. Briquetting is a relatively new technology in Nigeria as it is in most African countries. The expansion of the use of biomass as an alternative source of energy for heating applications depends basically on three factors: residue availability for briquetting, appropriate technologies and the market for briquettes. Attempts have been made in developing machines for briquetting of biomass in developing countries but the numerous failures of these machines in almost all developing countries have inhibited their extensive exploitation. There is need to develop appropriate machines for the briquetting of biomass in rural Nigerian communities. Such machines would address the issue of technical difficulty in the operation, maintenance and reproducibility of the machine; excessive initial and operating cost of the machines; the use of locally available fabrication material, environmentally friendly and culturally fitting, and commercialization of biomass briquettes. Hence it is imperative that appropriate machines be developed for the commercialization of biomass production beyond household production and use if this sector of the energy industry is to be developed and advanced.

Keywords: Biomass, briquetting, appropriate technology, rural communities

1.0 Introduction

In recent years, there has been a strong worldwide interest in the development of technologies that exploit renewable energy sources otherwise known as Green Energy, both for environmental and economical reasons. Biomass defined as different materials of biological origin mainly plant material and animal wastes (Sampson et al., 1993; Trebbi, 1993), used primarily as domestic energy source is naturally abundant and present a renewable energy opportunity that could serves as an alternative to fossil fuel. Even though increased fossilfuel use has prompted a reduction in biomass consumption for energy purposes over the past 50 years, biomass still provides about 1.25 Billion tons of oil equivalent (Btoe) or about 14% of the world's annual energy consumption (Werther et al., 2000; Purohit et al., 2006; Zeng et al., 2007). Among the various sources of renewable energy, biomass or bio-residues of which agricultural residues form a major component are generally considered a waste in poor and developing countries like Nigeria. Tumuluru et al. (2010) reported that wood wastes, agricultural straws, and grasses are the most prominent biomass energy sources and if properly managed, offers many advantages among which is being a renewable and sustainable energy feedstock. In addition to that, it can significantly reduce net carbon emission when compared to fossil fuel.

2.0 Nigeria and its Energy Situation

The energy situation in Nigeria could best be described as deplorable especially in the rural areas. Most rural communities lack access to electricityand the cost of electricity isalso too high for them to afford. Energy usage by rural dwellers has been mainly for cooking or heating applications. Njenga et al. (2009) reported that kerosene and charcoal are by far the most commonly used sources of cooking fuel in rural communities. They further added that shortage of low cost sources of energy has resulted in families abandoning traditional foods that require long cooking time, to prepare faster cooking ones. This is a common trend in Nigeria communities both in the rural and urban communities. Others have resulted to using unhealthy materials as sources of energy such as plastics, with potential negative health impacts.

Kerosene has become a scarce commodityin Nigeria and when available is usually very expensive. The Nigerian National Petroleum Corporation (NNPC)/ Capital Oil Initiative on kerosene distribution currently going on in Nigeria aimed at selling kerosene directly to the people at the official rate of 50 per liter reaches only selected few within the major cities like Abuja, Lagos and Port Harcourt without any consideration for those in the rural areas. Wood fuel on the other hand is now becoming out of reach due to constant and continuous deforestation, pushing further and further away which would soon be too far away or too scarce to reach (Hood, 2010). It is not uncommon for women in rural communities to spend more than 6 hours each day collecting and preparing wood despite the fact that there are often vast quantities of biomass residues and wastes available with the potential to be used as fuel but generally considered as waste. Hood (2010) further added that the unsustainable harvesting of wood fuel from forest has led to enhanced desert encroachment and has contributed to environmental degradation witnessed in terms of climate change manifestation. It is clear that now more than ever, alternative fuels need to be found.

Biomass residues can be found in significant quantity in many rural communities in Nigeria mainly from crop wastes or agricultural residues which include the residues that remain in the field after harvesting or processing. Typically about 3-5 tons of agricultural residues are produced per acre in rural areas (Stanley, 2003). With the diminishing forest resources and increasing population within and outside the rural communities, there is a pressing need to develop ways of utilizing biomass as a sustainable source of energy. Not only to meet energy demand in an environmentally friendly manner, but also to address pressing human health issues resulting from emission due to incomplete combustion of loose biomass.

The expansion of densification of biomass depends basically on three factors as identified by Felfli et al. (2011): residue availability for briquetting, adequate technologies and the market for briquettes. The market for alternative energy sources exist in Nigeria due to the high cost of existing energy sources but the challenge is in developing appropriate technologies that would produce cost effective briquettes that would be competitive on the energy market. It is imperative that more research be focused on the development of appropriate technology for the expansion of this sector as it is the area of pressing need in Nigeria.

3.0 Biomass Densification

Biomass densification represents technologies for converting agricultural residues into solid fuelwith or without binders in improving the handling characteristics of the material for transport, storage, and usage. These technologies include briquetting, pelletizingand agglomeration. During

densification, loose and smaller biomass is mechanically compressed, increasing its density about ten folds (Tumuluru et al., 2010) as well as its calorific value. Biomass briquetting is a viable and attractive solution in utilizingit for fuel applications. It is usually performed using hydraulic, mechanical, or roller presses. There is a real opportunity in rural communities in converting the enormous biomass waste generated from agricultural activities into fuel briquettes.

3.1 Estimating biomass availabilityin Nigeria

Agricultural residues have been reported to be a large and an underexploited energy resource, almost always underestimated (Rosillo-Calle, 2007). This is mainly due to the complex nature of biomass production and use, as well as its economics. A number of factors have been identified as constraints to effectively estimating biomass feedstock potential. According to Oliveira and Franca (2009), predicting the exact amount of residues produced for a specific crop is very difficult due to differences in agricultural practices adopted in different geographical locations even within a particular location, seasonal and cultivar variability, amongst other less relevant factors. Rosillo-Calle (2007) noted that difficulties in estimating resource availability and long-term sustainable productivity is also contributing factor given the large range of conversion technologies, as well as ecological, social, cultural and environmental considerations.

Furthermore, estimating biomass energy use is also problematic due to the range of biomass energy end-uses and the alternative and competing uses of biomass resources which include animal feed, materials for construction or for natural replenishment of farm lands. The potential of dedicated energy crops or forestry in replacing traditional biomass is considerably uncertain since the traditional sources of biomass they could replace, such as residues from agriculture, forestry and other sources have a much lower and varied energy value. In some situations, data on biomass resource that are site-specific cannot be compared with data from other locations as there are no unified standard unit for quantifying or measuring various forms of biomass resource. All these factors make it very difficult to estimate biomass resource potential for different locations especially on a global scale.

The availability of agricultural residues as energy feedstock is a function of the amount produced, the residue-to-crop ratio, the collection efficiency and the amount used in other competing applications, such as fodder for livestock, feedstock for fertilizer, materials for construction and direct burning in boilers and furnaces (Purohit et al., 2006). It has been suggested that, after accounting for seasonal variation and also, for the use of agricultural residues for soil conservation and livestock feed, an average of only 15% of the total residue production would be available for industrial energy generation (Bowyer and Stockmann, 2001). The amount of residue produced by a specific crop is usually measured by the Residue Coefficient which is calculated as the residue-to-crop ratio (weight by weight) considering a percent recovery fraction ranging from 15 - 70% depending on the agricultural practices adopted and on the intensity of other competing applications on the location (Purohit et al., 2006; Lora and Andrade, 2009).

3.2 Manual presses in developing countries

A number of briquetting machine have been developed for use in developing countries. It has been observed that the briquetting technology suitable for developing countries is what Zhanbin (2003) termed normal temperature briquetting technology for biomass. It is so termed because briquetting is done at the material original moisture content (usually between 8 – 35% (wet basis), with no requirement for electrical heating as in the case of screw briquetting and no

temperature control is required. The system complexity, the area requirement and energy consumption are greatly reduced. The pressure required for the process is also reduced and the cost on drying is saved. It has been observed that in most of the briquetting presses commonly used in rural communities, human strength is required for pressure application resulting in inconsistency in the density of the briquettes. Also, they are characterized by low productivity. Some researchers (Oladeji, 2011; Adekoya, 1998; UNEP, 2009; Bogale, 2009; Njenga et al., 2009; Davison, 2010; Uzoma et al., 2011) have developed some manual or low pressure briquette presses based on this technology.

4.0 Limitations of Existing Briquetting Machines

The constraint in the advancement of biomass briquetting in African and in Nigeria particularly has been associated with the development of briquetting press for local commercial manufacture. The existingbiomass briquette machines (Oladeji, 2011; Adekoya, 1998; UNEP, 2009; Bogale, 2009; Njenga et al., 2009; Davison, 2010;Uzoma et al., 2011) in rural communities address the utilization of waste biomass for briquette production at the household level. As earlier noted, the expansion of the use biomass as an alternative source depends on three factors, two of which are the development of appropriate technology and the market for the briquettes (Felfli et al., 2011). The development of appropriate briquette machines for rural communities should go beyond designs for household use to commercial scale. Some of the commercial limitations associated with the existing machines are:

i. The use of human strength in the application of pressure for biomass densification making them gender sensitive and producing poor quality briquettes. This has necessitated the use of hydraulic jack in the design of some of the machines.
ii. All of the reviewed machines used in rural communities are of low production capacities making them unprofitable for commercial use. The low production capacity is mostly associated with the time spent in the ejection of the compressed biomass from the moulds.
iii. Due to the above problems, the machines lack commercial scale-up capabilities hence are limited to household use only, making the marketing of the briquettes unprofitable.

The numerous failures of these machines have been recorded due to attempts to use them for commercial production of biomass briquettes. Thus, they have been limited to household production due to their inappropriateness for commercial use. All of these aforementioned problems need to be addressed before significant progress can be made in the briquetting of biomass in Nigeria.

5.0 Appropriate Technology, Briquetting And Rural Development

A major challenge today in most developing countries is to articulate an effective approach to ensure thatbenefits from development are within people's reachregardless of where they live.Appropriate technology as a developmental approach, isintended to address such socioeconomic problems,especially in the rural and informal sectors.The technological orientation of thisdevelopment paradigm has been variously calledintermediate, progressive, alternative, light-capital,labor-intensive, indigenous, appropriate, low-cost,community and soft technology. According to Akubue (2000), appropriatetechnology is defined as an approach to developmentthat not only emphasizes job creation andoptimum use of existing skills and resources but alsobuilds on the skills and resources to raise the productivecapacity of a community.Dunn (1978) called it a completesystems approach to development that is both self-adaptive and dynamic, because as its users become wealthier and more skilled, they can both afford and also use more expensive technical means. It can therefore be said to be an effective

way of gradually adopting modern technology. The focus of appropriate technology in rural areas is tailored to serve the particular needs of a given people or community by securing the "best" alternative there is for the set of circumstances peculiar to that community.

Singer (1985) attributed the growing poverty in most developing countries in part to the rapid growth in modern sectors of the economy that is sustained with the most advanced imported technologies. Decades of massive importation of advanced technologies and the implementation of large-scale, capital-intensive production methods in developing countries have revealed the shortcomings of such an approach. First of all, the strategy entails the employment of capital-intensive technology in countries that are short of capital but endowed with surplus labor. Third World countries, by opting for capital-intensive production technology in spite of their shortage of capital, can only afford to create a few jobs for a small number of people due to limited educational and technical capabilities. This implies that several developing countries equip only a very small proportion of their labor force with the means of increasing production. Nigeria, with its low level of technological development especially in the agricultural sector, has to pay keen attention to the type and nature of technology developed for the rural populace for the briquetting of biomass. The technological skills of the rural people can be said to be very low hence appropriate technologies that would cater for their level of skill need to be deployed to encourage small scale briquetting enterprises.

Biomass provides an average 35% of the energy needs of three-quarters of the world's population which rises to between 60 and 90% in poorest developing countries (Rosillo-Calle, 2007; Lee et al., 2007). Today, biomass energy continues to be the main source of energy in many rural communities in Nigeria albeit in its traditional forms. In these rural communities, it is still a common practice to burn organic waste (biomass) in homes or garbage dumps. Although the direct combustion of charcoal and agricultural wastes is extensively used, this usage of biomass may not be generally considered "suitable" or "efficient" for direct energy applications (Ellegard and Egenéus, 1993; Teixeira et al., 2011). This practice results in the waste of energy, environmental pollution and health problems. The use of biomass as an energy resource is insignificant compared to the volume produced annually in the country. However, it has been projected that by 2030, biomass will be an outstanding solution for individual heating, dominated by wood chips, wood logs and pellets in rural areas (Cioablă and Ionel, 2011).

A need exists in rural communities of Nigeria for long-term sustainable development in job and wealth creation. Globally, poverty is consistently higher in the rural communities as opposed to the urban areas. These rural communities are mostly agricultural based and hence agriculture plays a key role in the economic development of these areas. However, the role of agriculture as a job and local wealth creator has declined in recent years (Cowan, 2002). Twidell and Weir (2006) noted that the utilization of renewable energy application such as biomass briquetting has been identified to favour rural development and leads to increased cash flow in the rural economy. Biomass may offer an opportunity to grow, process, and transport lignocellulosic biomass and rebuild these local agriculture-based economies. The conversion of lignocellulosic biomass to bio-based products promises to have significant impact on rural communities in Nigeria either through job creation or personal savings on expenditure on energy resources. The transition to the use of biomass as energy resource offers commercial opportunity, resource and environmental sustainability, and a more sustainable development practices resulting from more intensive agricultural and forestry utilization, and the accompanying deployment of appropriate technology

(Nelson et al., 2011). Such a transition can create opportunities for new rural bio-based economy and wealth for the rural populace, offering solution to indiscriminate burning and disposal of agricultural wastes. As Grassi (1997) in his study revealed that renewable energy sector is labour intensive, and is thus a significant source of employment.

6.0 CONCLUSION

The need for alternative energy source is staring the Nigerian populace in the face and biomass residues present a readily available solution to the alternative energy need of the people. It is clear that the biomass is in abundance in Nigeria especially in the rural communities where agriculture is the main stay of the people. The densification of the biomass using existing low pressure machines may not bring about the needed advancement and commercialization of the briquettes hence the need to develop appropriate machines for the commercialization of biomass briquetting in Nigeria while considering the technical ability of the rural people who would use these machines. This is expected to bring about additional cash flow into the rural economy as well as the corresponding employment opportunities it would offer.

REFERENCES

Adekoya, L. O. (1998). Briquetting of agricultural wastes: A preliminary study. Proceedings of the CIGR Inter-Sections Symposium. National Center for Agricultural Mechanization, Ilorin, Nigeria, pp. 218 – 225.

Akubue, A. (2000). Appropriate technology for socioeconomic development in third world countries. The Journal of Technology Studies XXIV, number 1.

Bogale, W. (2009).Preparation of charcoal using agricultural wastes. Ethiopian Journal of Educ. & Sc., Vol. 5 No 1, pp. 79 – 91.

Bowyer, J. L. and Stockmann, V. E. (2001).Agricultural residues. Forest Products Journal, 51, 10 - 21.

Cioablă, A. E. and Ionel, I. (2011). Biomass waste as a renewable source of biogas production – experiments. In: Alternative Fuel, M. Maximino (Ed.). Published by InTech.

Cowan, T. (2002). Value-Added Agricultural Enterprises in Rural Development Strategies. Washington, DC: Congressional Research Service, The Library of Congress.

Davison, S. C. (2010). Non transport biofuels.A Presentation by Pipal Ltd. World Biofuels Market.

Dunn, P. D. (1978). Appropriate technology-Technology with a human face. New York: Schoken Books.

Ellegard, A. and Egenéus, H. (1993). Urban energy: exposure to biomass fuel pollution in Lusaka. Energy Policy, 21(5): 625 – 622.

Felfli, F. F., Mesa P, J. M., Rocha, J. D., Filippetto, D., Luengo, C. A. and Pippo, W. A. (2011).Biomass briquetting and its perspectives in Brazil. Biomass and Energy (35): 236 – 242.

Grassi, G. (1997). Operational employment in the energy sector.A presentation at the Tagung des SPD – Umweltforums.

Hood, A. H. (2010). Biomass briquetting in Sudan: A feasibility study. The United States Agency for International Development (USAID) and the Women's Refugee Commission.

Lee, S., Speight, J. G. and Loyalka, S. K. (2007). Handbook of alternative fuel technologies. Taylor & Francis Group, LLC.

Lora, E. S. and Andrade, R. V. (2009).Biomass as energy source in Brazil. Renewable and Sustainable Energy Reviews, (13): 777 - 788.

Nelson, P., Hood, E. E. and Powell, R. (2011). The Bio-economy: A new era of products derived from renewable plant-based feedstocks. In: Plant Biomass Conversion, First Edition, E. E. Hood, P. Nelson and R. Powell (Eds.). John Wiley & Sons Inc.

Njenga, M, Karanja, N., Prain, G., Malii, J., Munyao, P., Gathuru, K., and Mwasi, B. (2009).Community-based energy briquette production from urban organic waste at Kahawa Soweto informal settlement, Nairobi.Urban Harvest, Peru.Working paper series, Paper 5.

Oladeji, J. T. (2011). Comparative fuel characterization of briquettes produced from two species of corncob. Researcher, 3(4).
Oliveira, L. S. and Franca, A. S. (2009).From solid bio-wastes to liquid biofuels. In: agricultural wastes: Agriculture Issues and Policies Series. G. S. Ashworth and P. Azevedo (Eds.).Nova science publishers, Inc.

Purohit, P., Tripathi, A. K. and Kandpal, T. C. (2006).Energetics of coal substitution by briquettes of agricultural residues.Energy (31): 1321 – 1331.

Rosillo-Calle, F. (2007).Overview of bioenergy. In: The Biomass Assessment Handbook: Bioenergy for a Sustainable Environment. F. Rosillo-Calle, P. de Groot, S. L. Hemstock and J. Woods, (Eds.). Published by Earthscan, UK.

Sampson, R. N., Wright, L. L., Winjum, J. K., Kinsman, J. D., Benneman, J., Kursten, E., Scurlock, J. M. O. (1993). Biomass management and energy. Water, Air, and Soil Pollution, 70(1–4), pp. 139–59.

Singer, H. (1985). Appropriate technology and basic-needs strategy. In M. Carr (Ed.), The AT reader: Theory and practice in appropriate technology (pp. 27-28). Croton-on-Hudson, NY: Intermediate Technology Development Group of North America.

Stanley, R. (2003). Fuel Briquette making. Legacy Foundation.

Teixeira, S. R., de Souza, A. E., Peña, A. F. V., de Lima, R. G. and Miguel, A. G. (2011). Use of charcoal and partially pyrolysed biomaterial in fly ash to produce briquettes: Sugarcane bagasse. In: Alternative Fuel, M. Maximino (Ed.). Published by InTech.

Trebbi, G. (1993). Power-production options from biomass: The vision of a southern Euorpean utility, Bioresour. Technol., 46: 23 – 29.

Tumuluru, J. S., Wright, C. T., Kenny, K. L., and Hess, J. R. (2010).A review of biomass densification technologies for energy application. A report prepared for the U. S. Department ofEnergy by the Idaho National Laboratory, Biofuels and Renewable Energy Technologies Department, US.

Twidell, J. W. and Weir, A. D. (2006).Renewable energy resources.Second Edition.Taylor and Francis Group, London and New York.

UNEP (2009).Converting waste agricultural biomass into a resource - Compendium of technologies.United Nations Environmental Programme, Division of Technology, Industry and Economics, International Environmental Technology Centre Osaka/Shiga, Japan.

Uzoma, C. C., Okafor, I. F. and Okpara, C. G. (2011). Fuel briquettes technology can save Nigeria's trees. Continental J. Environmental Sciences 5 (1): 20 – 28.

Werther, J., Saenger, M., Hartge, E. U., Ogada, T. and Siagi, Z. (2000).Combustion of agricultural residues.Progress in Engineering and Combustion Science, (26): 1 – 27.

Zeng, X. Y., Ma, Y. T. and Ma, L. R. (2007).Utilization of straw in biomass energy in China.Renewable and Sustainable Energy Revisions, (11): 976 – 987.

Zhanbin, C. (2003). Normal temperature briquetting technology for biomass with original moisture content.International Conference on Bioenergy Utilization and Environment Protection, 6th LAMNET Project Workshop Proceeding, Dalian, China.

REPOSITIONING AGRICULTURAL DEVELOPMENT IN AFRICA THROUGH APPROPRIATE TECHNOLOGY TRANSFER

[1]Obi, O. F., [2]Nwaikaire, J. N.,Okonkwo, W. I., Ugwuishiwu, B. O. and Anyadike C. C.
Agricultural and Bioresources Engineering Department, University of Nigeria,
Nsukka, Nigeria.
[1]francis.obi@unn.edu.ng, [2]joel.nwakaire@unn.edu.ng

ABSTRACT

In Africa, majority of the populace are involved in agriculture and it plays a significant role in the Gross Domestic Product (GDP) of African countries. The advancement in agricultural technology frontiers over time has resulted in continuous upward shifts in the production, distribution and consumption of agricultural produce worldwide. Such dramatic shifts in the technology frontier have increased the technology gap between crops and regions because of differences in the physical and institutional environments affecting the adoption of these technologies. This study is a synthesis of agriculture technology transfer in Africa which in addition to defining technology transfer examines the concept of technology transfer, its need in African agriculture, barriers and opportunities to its adoption and adaptation to the local environment, the needed technology transfer drivers in African agriculture, the process for effective technology transfer and a look at the way forward for technology transfer in African agriculture.

Keywords: Agriculture, appropriate technology, development, technology drivers

1.0 Introduction

In Africa, majority of the populace are involved in agriculture and it plays a significant role in the Gross Domestic Product (GDP) of African countries. The main agricultural activities include crop production, livestock production and fishing. In Gambia for example, the main stay of the economy comes from the agricultural sector and employs about 75% of the labour force contributing about 28% of the GDP (Sanyang et al., 2009). Today, we live in a world that is geographically, culturally, politically, economically and technologically diverse yet, the power of communications has made the world a global village. The advancement in agricultural technology frontiers over time has resulted in continuous upward shifts in the production, distribution of agricultural produce worldwide. Most of the upward shifts have been incremental, arising from improvements in one or several technical and institutional components (e.g., crop rotations, soil protection, land tenure arrangements, hybrid seed technology, the improved seed and fertilizer based Green Revolution, and agricultural biotechnology) (Maredia et al., 1996). Such dramatic shifts in the technology frontier have increased the technology gap between crops and regions because of differences in the physical and institutional environments affecting the adoption of these technologies. In Africa, technology has had a limited impact on agricultural productivity (Maredia et al. 1996). The current level of transfer and adoption of technology in Africa does not approach the gains realized elsewhere where the technologies have been transferred to. In developed countries, the development, adoption of new techniques combined with institutional, and organizational changes, have increased agricultural productivity and decreased costs. If the world agricultural sector is growing and technological means are available for agricultural development, why are the African countries still experiencing poor performance and widespread

poverty in agriculture? How can this trend be reversed? These are the questions this paper aims to address. This study is a synthesis of agriculture technology transfer in Africa which in addition to defining technology transfer examines the concept of technology transfer, its need in African agriculture, barriers and opportunities to its adoption and adaptation to the local environment, the needed technology drivers in African agriculture, the process for effective technology transfer and a look at the way forward for technology transfer in African agriculture.

2.0 What is Technology Transfer?

Technology Transfer (T^2, often pronounced "T-two" or "T-square") is a process of communication. "Technology Transfer is a process by which existing technology is transferred or transformed to fulfill the user's needs" (Krull, 1990). Wallace et al. (1998) was of the opinion that a more complete definition was by Hodgkins (1989) who stated that "Technology transfer is the process by which research and other new technologies are transferred into useful processes, products, and programs." Hodgkin's definition gives a broader view as to what technology transfer is as well as its components. Wallace (1998) in analyzing Hodgkins (1989) definition stated that every phrase of the definition is significant in that: "The process" defines T^2 as a methodology and not a "thing"; "Research findings" suggests that research is the genesis of new technology; "Other technologies" suggests that new technologies can also emerge from other fields of endeavour; "Are transferred into" implies that an adoption of the technology takes place, and not simply its use; "Processes" are techniques for accomplishing works; "Products" are actual tools, materials, and other hardware or software; and "Programs" mean the institutional garnering of resources to accomplish the works. Schmitt et al. (1989) definition suggests that technology transfer refers to a series of inter-related activities leading to the adoption of a new product or procedure of doing things by a group of users. They further emphasized that new product or procedure could mean any improvement over an existing technologies or processes, not necessarily a chronological recent invention. It goes on to say that "that technology transfer is not simply information dissemination; that is, it is not simply sending out information-whatever form- and then passively awaiting its use. Technology transfer is a more active term. It implies interaction between technology sponsors and users and results in actual innovation." This gives a very broad and detailed understanding of what T^2 is all about. The processes involved in T^2integrate multiple functions including organized research and development, design, production engineering, manufacturing, marketing, and other value-adding activities in a complex web containing multiple feedback loops (Kline and Rosenberg, 1986). Just like the innovation process loop, technology transfer is usually iterative; involving multiple transfer steps in which different stakeholders are actively involved.

Abramson et al. (1997) on the other hand defined technology transfer as the movement of technological and technology related organizational know-how among partners (individuals, institutions, and enterprises) in order to enhance at least one partner's knowledge and expertise and strengthen each partner's competitive position. This definition may not be applicable in the African traditional context as the aim of technology transfer is usually to meet the developmental needs of the people in terms of improved agricultural practices; increased productivity; and better management practices through developmental aid. It is usually not profit oriented at least within the African context as it is usually sponsored or supported by Non Governmental Agencies (NGOs). T^2 has in time past been seen as the exportation of sophisticated machineries from developed nations to under developed ones. This poor understanding of technology transfer has resulted in the abandonment of highly sophisticated and high cost machines in African. Some of

these machines were never unpacked from their boxes resulting in waste of resources, expiration of the machines without use and discouragement on the side of the donor nations. Technology transfer is much more about the people than it is about technology. It is about making the best technology both in terms of equipment and software, as well as processes available to the largest number of people possible. The transfer of technology is without borders. It could be confined to within a specific location, a nation, across countries and continents.

2.1 The Need for Technology Transfer in African Agriculture

The goal of technology transfer in agriculture between developed and developing countries is to help the least developed countries improve yield, boost socio-economic development and attain self-sufficiency in household food security. The idea is to help developing countries move from traditional based agriculture to technology based agriculture through the infusion of resources into research and development to produce chemicals, improve production and breeding techniques, better farm management skills, etc. (Sanyang et al, 2009). In the Gambia, women involved in horticultural crops have been reported to have been constrained with inappropriate use of agricultural technologies, inadequate supply of inputs, low crop yield and lack of access to the market. For these farmers, the transfer of technologies to address these constraints is imperative. Technology transfer helps in developing indigenous technological capabilities and meeting the broader socio-economic objectives of the people (Madanmohan et al., 2004). The technological gap in African agriculture has been largely attributed to the lack of techniques and low levels of technology adoption (Maredia et al., 1996). Agricultural productivity in Nigeria is on the downside due to the tedious nature of the operations associated with the tools and equipment used. The sector is now manned by the old and aged once while the young and the agile leave for the congested urban areas. Most tertiary institution graduates have continuously attributed their unwillingness to venture into agriculture due to the crude nature of the tools currently available for agricultural production. All these challenges culminate in the urgent need of the transfer of appropriate technologies to African countries.

3.0 The Concept of Technology Transfer

Technology transfer is generally seen as a mechanism through which improved and developed techniques, procedures and machineries are transferred from one location to another. The mechanism helps in building the technological capability of a country. Madanmohan et al. (2004) identified three different objectives or basis on which technology transfer is embarked on. These are:

i. Technology importation for import substitution: Here, the developing country imports appropriate technology or proven technology to develop an existing indigenous production system. Such technologies are targeted at specific agricultural sector of a country's economy with the aim of increasing productivity, management and marketing of agricultural produce in meeting the demand of the people and reduce dependency of foreign importation. Examples are the establishment of a rice irrigation system in Gambia in 1960 to increase production for its population and reduce the cost of imported rice (Sanyang et al., 2009).

ii. Technology importation to boost export oriented industries: The primary objective is to develop productivity to cater for export market. Sanyang et al. (2009) stated that countries exploit their own comparative advantages and utilize imported technology to capture foreign markets. Nigeria for example has in recent years been using its indigenous technology to boost local production of cassava and exploit the international markets for

sales of cassava starch and other derived products. This however has been a continual failure due to poor government policies and poor local technology. Transferring technologies from countries such as China and Thailand could be one way of penetrating the international cassava market.

iii. Technological importation to support indigenous capabilities: This option is utilized by countries that have attained a certain level of technological capability to compete in the international market (Kedia and Bhaghat, 1988). Technologies are transferred to boost the existing technology and compete better with major players in the foreign market.

African agriculture is in dire need of technologies that will help boost local production to meet the demand of the people. This should be the focus of African countries in the transfer of technologies from more developed countries – to boost local production. Other basis for technology transfer could further be exploited once the immediate production demand of the people has been met.

3.1 Barriers and challenges of technology transfer

The main barrier to technology transfer is the resistance to change (Wallace et al., 1998). A number of other barriers have been associated with technology transfer and they include: language barrier, culture differences, customary law, technological development maturity of the people or locality, economic strength, proximity of the locality to and from the donor location and available natural materials. These challenges are rather complex and their mix is dependent upon the provider and the receiver of the technology (Wallace, 1998). Furthermore, technology transfer practitioners over the years have been faced with the fact that it is almost impossible to keep pace with the need for T^2 in a highly accelerated changing world. This has mainly been attributed to the fact that there are so many advancement in technology itself, shifts in political and socioeconomic environments, changes in the workforce with differing characteristic needs, and evolutions that propel people into new and unknown jobs areas.

Within African countries, another major challenge has been in providing institutional framework for the utilization of the capacity to accept, adopt and adapt transferred technologies, where the capacity exists. Institutional development as well as the provision of basic infrastructure for technological innovation will remain a major concern for most developing countries in the next decade (Juma, 1994). But with well organized international co-operation programmes it is possible to promote the adoption of appropriate technologies in African countries, especially where the requisite capacity available. However, international co-operation is often seen as developmental aid in the traditional context but real international co-operation spans beyond aid; more of beneficial transaction for both the donor and the receiver. There is a general view that an increase in the flow of overseas developmentassistance would necessarily promote technological development in the developing countries. This view emanates from the assumption that development assistance could be used to cover the royalties that would otherwise be paid to suppliers of technology (Juma, 1994).

First, it should be noted that development assistance is not a major carrier of technology to the poor and developing countries (Juma, 1994). Juma added that in specific areas of technical co-operation, it is most often than not doubtful that aid programmes do make important contributions to technological development. Secondly, most development-assistance programmes focus on agricultural production, which has less potential for technological development than industrial production comprising of production, distribution and consumption. Increasing developmental

assistance or aid without redirecting the focus would simply make available more funds and machineries that the developing countries cannot utilize effectively. In essence, increases in aid flow cannot necessarily contribute to technological development.

What readily come to mind at the mention of the word technology is equipment, skills, managerial competence, and the technical specifications associated with the production of goods. Technology transfer is therefore widely perceived as mainly the flow of such production capacity as earlier stated. "This limited perception of technology has led to the false view that technological development is inherently an expensive process which must rely on external inputs and financial resources" (Juma, 1994).It therefore suggested that African countries abandon the use of this term and focus on accumulating technological capacity, which is the ability to generate and manage technical change (including the related skills, knowledge, and experience as well as institutional structures and networks). In this respect, technological development is a purposive and dynamic process that builds on period gains and is articulated through specific institutional arrangements or *firms*. It takes more than the mere act of investing in new production facilities to achieve development through technology transfer; concerted and guided efforts are needed.

4.0 Technology Transfer Drivers

Amponsah (1996) in his study on creating an enabling environment for the transfer of agricultural technology transfer identified some forces behind the growth in demand for agricultural Technology. It was noted that such drivers include interactions among some sets of processes which define a uniform framework for the transfer of agricultural technology in Africa. As research and science advance the frontiers of knowledge, it is important to bear in mind that such efforts must not lose sight of the guiding principles of sustainable development. Science and technology is like a listening-post at the outer edges of human perception. But science cannot work in isolation. For it to make maximum impact on the societies of tomorrow it must interact with politics, with democratic debate, and it must be geared towards defined goals (Brundtland, 1991). This is line with the agricultural technology transfer drivers identified. They were focused on institutional policies and they include:

1. Policies that influence the potential of agricultural technology input use through the development of resources which influence upwards the technology response function characterized as market incentives. Investment in agriculture be it human or material is tailored toward one goal: profit; it is imperative that institutions within African countries promote policies that show the benefit of the adoption of transferred technologies on the profits of those involved in agricultural production.
2. Policies that influence the effective demand for the technology by producing knowledge on its use (information flows and education), credit and assured markets for outputs characterized as institutions. There is need for agencies to integrate the marketing of technologies being transferred to the users as part of the technology transfer process. Appropriate agricultural technologies, trainings and related improvements in marketing methods are essential in enhancing agricultural productivity (Sanyang et al., 2009).
3. Policies that determine the growth in the supply of technology domestically or the transfer and commercialization through trade characterized as investment. This is tailored toward policies that encourage the adaptation and adoption of transferred technologies to the local environment. This can be achieved through partnership ventures between the donor agency and the local business men but plovies need to be developed to encourage such ventures.

4. Policies that help geographically dispersed technology to be distributed and also determine how they operate and characterized as infrastructure.

The study was concluded by stating that the four major elements that should provide the enabling environment in influencing technology adoption, transfer, and commercialization in African countries are market incentives, institutions, investment, and infrastructure which was called the four I's. The key catalysts for the successful functioning of the four I's are interactions among appropriate micro and macroeconomic policies and a well functioning system of governance. In Africa, these are the fundamental requisites for creating an enabling environment for technology transfer.

Some innovation policy measures with potential to encourage and create an enabling environment for the transfer of technology has been identified by the African Center for Technology studies, Nairobi, Kenya as reported in Juma (1994).

Policy Measure	**Examples**
Procurement	Central and local-government purchases and contracts, public corporations, R&D contracts, prototype purchases, setting of design and performance criteria, choice of priority technologies.
International trade	Trade agreements, technology-acquisition agreements, tariffs, foreign- exchange regulations, export compensation, import subsidies, licensing, infant industry protection, and negotiation.
Public enterprise	Innovation by publicly owned industries, setting up of new industries, pioneering use of new techniques by public corporations, participating in private enterprises.
Scientific and technical	Research laboratories, support of research associations, learned societies, professional and technical associations, research grants, setting up science parks.
Education	General education, universities, technical education, retraining, vocational education.
Information	Information networks and centres, libraries, advisory and consultancy services, databases, technology monitoring, liaison services, public awareness.
Financial	Grants, loans, subsidies, financial sharing arrangements, venture capital, provision of equipment, buildings or services, loan guarantees, tariff remissions, export credits.
Taxation	Company, personal, indirect, and payroll taxation, tax allowances, depreciation allowances, tax exemption for private foundations.

Legal and regulatory	Patents, utility models, plant-breeders' rights, environmental and health regulations, contractual arrangements, conventions, inspectorates, monopoly regulations.
Political	Planning, regional policies, honours or awards for innovation, encouragement of mergers or consortia, public consultation, creation of new institutions, setting up of research funds, initiating legal reforms.
Public services	Purchases, maintenance, supervision, and innovation in health service, public building, construction, transport, telecommunications, infrastructure; administrative guidance.
External assistance	External aid, technical assistance, training, information provision. International relations Sales organizations, trade and diplomatic missions (science attachés), technical co-operation, research representatives, international negotiations.

5.0 Effective Technology Transfer

Often times, attention has been focused on the latest technological innovation, neglecting the channel through which the technology gets to the people. For effective T^2 in agriculture, it is important to focus not only on the latest technological innovation as it applies to agriculture but also on the latest state of the practice of technological transfer. It is suggested that that a hands on practical guide or manual on systematic application of agricultural technology transfer be made available to T^2practitioners, mainly agricultural extension workers who are involved in the application of T^2. This will help bridge the gap between the state of the art technology and the state of the practice.

Effective technology transfer in African agriculture must be tailored towards the need of the people involved in agriculture. A knowledge and understanding of their needs and an internal environment for innovation is imperative for effective technology transfer. When technology is adopted or foisted without consideration for the local conditions and local capabilities, it generally turns into a disaster (Faiz and Cook, 1991). A participatory approach has always been an effective way of transferring technology to developing countries. It creates room for integration and sharing of knowledge, dexterity and access between the technical group and the receiver of the technology (Sanyang et al., 2009).The issue of monitoring and evaluation through discussions and field visits and on-farm trial demonstrations are vital in the effectiveness of the transfer of technology. The essence of monitoring and evaluation is to ascertain the appropriateness of the technology to the condition of the local people.

In the transfer of technologies, emphasis must be placed on transfer of appropriate technologies and not the high-tech innovation and development. Appropriate technologies are small scale technologies that are energy efficient, environmentally sound, labour intensive and can be controlled by the local community (Vergratgt, 2006). It is the kind of technology that can be effectively utilized and afforded by developing countries; it is immensely cheaper than the sophisticated, highly capital intensive technology of modern industry (Schumacher, 1973). Although this technology is termed “cheap” or “second hand”, it has been widely advocated as the right technology for rural development. The way forward with appropriate technology is to

combine its elements with some aspects of high technology into a new paradigm of sustainable technology (Vergragt, 2006).

Acquah and Gelaw (1996) noted that there is a gap between available technologies and implemented technologies. Implemented technologies are technologies that are actually used in production activities (Brenner, 1993). The spectrum of activities between the frontier of available technology and implemented technology reflects the economic environment - mainly economic policies (Acquah and Gelaw, 1996). The ability to implement a technology depends critically on agricultural policies, level of investment in human capital, and the transformation of the institutions needed to realize the full productive potential of new technologies (OECD, 1992). Without enabling policies that encourage the transfer and adoption of technologies, implementing transfer technologies may be difficult. In most African countries, there exist a number of transferred technologies that were not sustained due to poor government policies.

5.1 Adapting and Adopting Transferred Technologies

Adapting technology is the implementation of a technology from one industry or locality or condition to another. Technology transfer is only complete when it is adapted. In adapting a technology to a local condition, the local person must be willing to go through the adaptation of the technology and the technology must be applicable to the local conditions (Kalli, 1999). The local people have the responsibility to accept and adapt the technology to its local condition and also provide supporting role to the provider of the technology by providing adequate information on what works and what is acceptable within the local community. The same applies in adopting the technology in agricultural production activities. Technology transfer is indeed a partnership between the provider of the technology who has something to share and the receiver who will put it to good use. The two parties have roles to play if technology transfer is to be effective. However, the success of adapting and adopting transferred technologies cannot be achieved from any single technique in isolation, but will require an additive approach that builds on the complementarities of technical and institutional changes at various levels of the agricultural system, including the research and extension system, input delivery system, farm-level production, processing, and marketing. Technology transfer is only said to be successful if it results in a positive change (Wallace et al., 1998). The aim therefore is to have a successful technology transfer and not just an exchange of information. It is expected to bring about increase in income through the increased productivity, increase in knowledge and skills and improved quality of life of the people. The success of these interventions is expected to help African government to make necessary policy adjustment that would encourage the transfer of technology and its sustainability.

5.2 Technology Transfer: The Way Forward for African Agriculture

Agricultural system is viewed as a production-distribution-consumption sequence (PDCS) of physical transformations linked through transactions (Boughton et al., 1995). These physical transformations are governed by a production function that relates inputs to output (Maredia et al., 1996). Facilitating agricultural productivity requires increasing the productivity of the agricultural system's PDCS. This would cut across all the physical transformation components of agricultural production, i.e. the PDCS, inevitably leading to significant development in African agriculture. This can be accomplished by embracing and creating an enabling environment for technology transfer in these three areas as noted by Maredia et al. (1996):

1. Improving the techniques in each of the individual transformations that shift the production functions upwards (e.g., through improved seeds, agronomic practices, harvesting, storage, and processing techniques) thereby closing the technology gap. Shifting the existing technology frontier further meeting that of the advanced nations is a continuous process of generating new techniques, providing an enabling environment, and coordinating the different stages of the agricultural system;
2. Improving the environment that allows the realization of potential gains from technical advancements (e.g., timely and adequate supply of inputs, credit, access to markets, infrastructure). As earlier stated, technology transfer is more than the transfer of machineries but includes management and marketing practices; and
3. Improving the coordination between advancements in the technical frontier and the environment across different physical transformations (e.g., coordination between the development of improved cattle breeds that are more efficient in transforming feed, increased supplies of feed, and production contracts that facilitate the sale of increased milk and meat output) (Boughton et al., 1995). Also, it involves adapting transferred technologies to the local environment where it would be used.

The above three points present a sure path to technology transfer that would impact all the components of agricultural system in Africa, leading to improvements in techniques, environment, and coordination mechanisms. It is worthy of note that for these options to effectively close the technological gap between the existing indigenous technologies in Africa and those of the developing countries, they must be complemented by appropriate measures to close the "institutional gap." Institutional gap to be closed up include general policies affecting price, trade, and monetary; fiscal systems and specific laws and regulations concerning business development, intellectual property protection and environmental protection that affect decisions to import technologies and invest in adaptive or inventive research (Maredia et al., 1996).The needed policies for creating an enabling environment for adoption of appropriate technology in support of managing and sustaining agricultural production and marketing in Africa is lacking. The implementation of technology depends on the pattern or nature of incentives deriving from the underlying economic conditions with which producers are faced in making technology choices. Reforms of institutions and the development of investment and infrastructure can enhance the enabling environment for agricultural technology transfer (Amponsah, 1996). The determinants of long-term growth are typically good policies which typically translate into faster economic growth (Easterly, 1992).

5.0 CONCLUSION

The great deal of thought, effort and sharing have boosted technologies around the world especially in the agricultural sector and the need for technology transfer has been recognized to require even more acute effort. Appropriate human resource development is essential in the creation of the African people's capacity to absorb, adapt and manage scientific and technological knowledge, products and techniques being transferred. African countries should devote to strategies that close the technology gap by easing physical, economic, and social barriers to technology adoption to meet the challenge of increasing agricultural productivity. In addition to that, as developing countries is expected to put more concerted and guided effort towards effective technology transfer, it is important that those involved in the process bear the following in mind as noted by Schmitt et al. (1985):

1. People and organizations are naturally resistant to change.

2. Personal contact-the human element- is the most important factor in innovation diffusion and adoption.
3. Personal contact-through one-to-one technical assistance and special transfer agents – is expensive in the short run but immeasurable cost effective in the long run.
4. Effective communication of new ideas and techniques is best done through multiple channels: people, newsletter, case study reports, professional association network and publications. No one way will be enough.
5. The experience and endorsement of peers are very important elements in the widespread adoption of innovation and technology.
6. Acceptance of new technology takes time, a lot of work, and risk.

REFERENCES

Abramson, H.N., Encarnacao, J., Reid, P.R. and Schmock, U. (Ed.) (1997). Technology transfer systems o the United States and Germany, Fraunhofer Institute for Systems and Innovation Research, national academy of engineering, Washington D.C.

Amponsah, W.A. (1996). Creating an Enabling Environment for Agricultural Technology Transfer andCommercialization: A Comparative African Study. Proceedings of the Workshop on Commercialization and Transfer of Agricultural Technology in Africa Accra, Ghana. SD Publication Series, Office of Sustainable Development, Bureau for Africa.

Acquah,E.T. and Gelaw,B. (1996). Transfer of Agricultural Technology Through commercialization: Critical Issues for the 21st century. Proceedings of the Workshop on Commercialization and Transfer of Agricultural Technology in Africa Accra, Ghana. SD Publication Series, Office of Sustainable Development, Bureau for Africa.

Brenner, C. 1993. Technology and Developing CountryAgriculture: The Impact of EconomicReform. Paris: OCDE.
Brundtland, G. H. (1991). Environmental Challenges of the 1990's: OurResponsibility Towards Future Generations (The Tanner Lecture on Human Values, Clarence Hall, Cambridge).

Boughton, D., E. Crawford, J. Howard, J. Oehmke, J.Shaffer and J. Staatz. 1995. A Strategic Approachto Agricultural Research Program Planning in Sub-Saharan Africa. Michigan State University International Development Working Paper No. 49. East Lansing, Michigan: Michigan State University.

Juma, C. (1994). Promoting International Transfer of Environmentally Sound Technologies: The Case for National Incentive Schemes. In: Helge OleBergesen and Georg Parmann (eds.), Green Globe Yearbook of International Co -operation on Environment and Development 1994 (Oxford: Oxford University Press),137–148.
Easterly, W. 1992. Projection of Growth Rates. Outreach5. Washington, DC: World Bank.

Faiz, A. and Cook, P. (1991). The twinning of road agencies as a medium for technology transfer. The World Bank, OECD Seminar on Technology Transfer and Adaptability in Developing Nations and Economies in Transition.

Hodgkins, E.A. (1989). Technology transfer in selected OECD countries. Prepared for Federal Highway Administration, U.S. Department of Transportation, EAH and Associates, North Carolina.

Kalli, A. (1999). One experience in technology transfer. National Organization for Technocal Control of Public Works, Algeria, OECD Seminar on Technology Transfer and Adaptability in Developing Nations and Economies in Transition.

Kedia, B.L. and Bhaghat, R.S., 1988. Cultural constraints on transfer of technology across nations: Implications for research in international and comparative management. Academy Manage. Rev., 13(4): 559-571.

Kline, S.J. and Rosenberg, N. (1986). An overview of Innovation, In: Positive sum Strategy. R. Landau and N. Rosen berg (Eds.), National Academy Press, Washigton, D. C., pp. 275 – 305.
Krull, R. (1990). OECD seminar on technology transfer and adaptability in industrialized nations. Summary report produced by University of Florida Transportation Research Center.

Maredia,M., Howard, J.A., Farrelly, L., Kajisa, K., Boughton, D., Rubey, L., Shaffer, J., Oehmke, J. (1996). Technology frontiers and agricultural transformation in sub-saharan Africa. Proceedings of the Workshop on Commercialization and Transfer of Agricultural Technology in Africa Accra, Ghana. SD Publication Series, Office of Sustainable Development, Bureau for Africa.

Madanmohan, T.R., U. Kumar and V. Kumar, 2004.Import-led technological capability: A comparativeanalysis of Indian and Indonesian manufacturingfirms. Technovation, 24: 979-993.
OECD, 1992. Technology and the Economy: The KeyRelationships. Paris.

Sanyang, S.E., Kao, T., Huang, W., 2009. The impact of agricultural technology transfer to women vegetable production and marketing groups in the Gambia. World Journal of Agricultural Sciences 5 (2): 169-179.
Schmitt, R. P., E. A. Beimborn, and M. J. Mulroy. 1985. *Technology Transfer Primer*. FHWA-TS-84-226, University of Wisconsin, July.

Schumacher, E.F., 1973. Small id beautiful: Economics as if people mattered. London: Blond and Briggs, Ltd.

Vergragt, P.J., 2006. How technology could contributeto a sustainable world. GTI Paper Series 8, the Tellus Institute.

Wallace, C.E., Anderson, J.A. and Wilson, E.M. (1998). Transportation technology transfer: A primer on the state of the practice. Transportation Research Circular, No. 488.

PRODUCTION OF BIODIESEL FROM USED VEGETABLE OIL

[1]Alabadan B.A.and J. A. Godwin

Department of Agricultural and Bioresources Engineering,
Federal University of Technology, Minna, Niger State
[1]Corresponding author e-mail:topealabadan@yahoo.co.uk

ABSTRACT

Biodiesel is a clean burning diesel fuel processed from natural and renewable biological sources such as waste cooking oil, rape seed, jatropha seed, animals fats and refined bleached deodorized palm oil. The objective of this work was to produce biodiesel from used vegetable oil using transesterification method. The transesterification of used cooking oil with short-chain alcohols, in the presence of base catalyst sodium hydroxide (NaOH) and methanol as solvent, by means of single step batch transesterification process in order to obtain biodiesel fuel was studied using a reaction ratio of 6:1 for alcohol to oil ratio. The oil was heated in a water bath. The process variables that were investigated are catalyst concentration and reaction time. The variable that is fixed throughout the whole experiment is quantity of used vegetable oil used, mixing degree of mechanical stirrer at 1300 rpm and the alcohol to oil ratio. The oil was divided into three samples. The biodiesel yield for the samples are 58ml, 79ml and 70mlrespectively while the glycerine yield for the samples are 19ml, 19ml and 20ml respectively. The reaction times for the three samples are 60, 90 and 120 minutes respectively. The best result for highest yield and highest purity is at 90 minutes reaction time and 1.5g catalyst concentration. Sample 2 was found to have the highest cetane rating closer to the ASTM standard which implies that sample 2 will be a more efficient fuel than the other two samples, guarantee smooth running of the engine as well as burn cleaner.

Keywords: Vegetable Oil, Biodiesel,Transesterification, Yield, Characterization

1.0 Introduction

The world consumption of fuels is undoubtedly unstable causing world economic crisis. There is a rising demand to globally provide renewable energy by means of a sustainable and ethical approach (Meher*et al.*, 2006). Biodiesel is defined as mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats which conform to American Society for Testing and Materials, ASTM D6751 specifications for use in diesel engines. It is a clean burning alternative fuel, produced from domestic, renewable resources. Biodiesel contains no petroleum, but it can be blended at any level with petroleum diesel to create a biodiesel blend. Biodiesel is simple to use, biodegradable, nontoxic, and essentially free of sulphur and aromatics.

There are three generations of biofuels. First-generation biofuels are biofuels made from sugar, starch, vegetable oil, or animal fats using conventional technology. Their use in producing biofuels has been criticised for diverting food away from the human food chain, leading to food shortages and price rises. Second generation biofuel production processes allow biofuel to be derived from any source of biomass, not just from food crops such as corn and soy beans but also from waste cooking oil (Felizardo*et al.,* 2006). Algae fuel, also called oilgae or third generation biofuel, is a biofuel from algae.

Biodiesel is made through a chemical process called transesterification whereby the glycerine is separated from the fat or vegetable oil (Fukuda *et al.*, 2001). The process leaves behind two products: methyl esters or biodiesel and glycerine. Biodiesel is much cleaner than fossil-fuel diesel. It can be used in any diesel engine with no need for modifications. In fact diesel engines run better and last longer with biodiesel. Moreover, it can easily be made from common waste product, used cooking oil. Biodiesel is better for the environment because it is made from renewable resources and has lower emissions compared to petroleum diesel (Ramadhas*et al.*, 2005). It is less toxic than table salt and biodegrades as fast as sugar.

Biodiesel is a fuel made from natural, renewable sources, such as new and used vegetable oils and animal fats, for use in a diesel engine. Biodiesel has physical properties very similar to petroleum-derived diesel fuel, but its emission properties are superior (Demirbas, 2008). Using biodiesel in a usual diesel engine substantially reduces emissions of unburned hydrocarbons, carbon monoxide, sulphates, polycyclic aromatic hydrocarbons, nitrated polycyclic aromatic hydrocarbons, and particulate matter (Lakshmi*et al.*, 2010). Diesel blends containing up to 20% biodiesel called B20 can be used in nearly all diesels powered equipment, and higher-level blends and pure biodiesel, B100 can be used in many engines with little or no modification. Lower-level blends are compatible with most storage and distribution equipment, but special handling is required for higher-level blends. One of the most used renewable energy is biodiesel which is the most common biofuel in Europe.

Biodiesel can be used in any diesel engine when mixed with mineral diesel. In some countries manufacturers cover their diesel engines under warranty for 100% biodiesel use. Many people have run their vehicles on biodiesel without problems. However, the majority of vehicle manufacturers limit their recommendations to 15% biodiesel blended with mineral diesel. In many European countries, a 5% biodiesel blend, B5 is widely used and is available at thousands of gas stations. Biodiesel can be made from waste and virgin vegetable and animal oil and fats (lipids) (Ramadhas*et al.*, 2009). Virgin vegetable oils can be used in modified diesel engines. In fact, the diesel engine was originally designed to run on vegetable oil rather than fossil fuel. There are also studies and efforts to commercialize biodiesel from algae.

Table 1 shows a comparison of chemical properties and fatty acid composition (%) of UCO. UCO has higher specific gravity because it has much residue such as water as water has mixed inside the UCO because of condensation of cooking process. Therefore, the density of UCO is high.

Table 1. Chemical properties and fatty acid composition (%) of UCO

Property		UCO
Palmitic acid	C16:0	16
Stearic acid	C18:0	5.21
Oleic acid	C18:1	34.28
Linoleic acid	C18:2	40.76
Specific gravity		0.92

From Table 2, some significant differences were found between Reference (REF) and biodiesel fuel. The reference fuel (REF) is a typical low sulphur diesel fuel similar to those available in Spanish petrol stations in winter (Magín*et al.*, 2008).

Petroleum processes are associated with incessant oil spillage that affect land and water resources of the environment, glass flaring, global warming and climate change which has threatened the health of human beings living in the areas were these crude is being refined and very unstable Petroleum price. It has become necessary to sought for alternative means to source for energy. A major benefit of biodiesel is lower emissions. Biodiesel is environmentally friendly and renewable.

Most used vegetable oil (UVO) ends up in the sewers and landfills where it does no good and doesn't offset any fossil-fuel use. Converting it to biodiesel is a much better option, a social service. Reduce, reuse, and recycle. The US produces an estimated 4.5 billion gallons a year of used cooking oil, and most of it goes to waste. The objective of this paper is the production of high quality methyl ester and environmental friendly biodiesel, from Used Cooking Oil

Table 2.Specifications of biodiesel fuels

Properties	REF	UCO
Density at 15 °C (kg/m3)	834	887
Kinematic viscosity at 40 °C (cSt)	2.72 5.16	
Gross heating value (MJ/kg)	45.54	39.26
Lower heating value (MJ/kg)a	42.49	36.59
Acid number (mgKOH/g)	0.10	0.55
% C (wt.)	86.13	76.95b
% H (wt.)	13.87	12.14b
% O (wt.)	0	10.91b
Sulphur content (ppm wt.)	34	0b
Water content (ppm wt.)	57	466
IBP (°C)	172	320
T10 (°C)	211	325
T50 (°C)	270	333
T90 (°C)	340	356
Molecular weight 211.7c	293.2b	
Stoichiometric fuel/air ratio	1/14.67	1/12.55
CFPP (°C)	−18	−6
Iodine number-	97.46	
Renewable fraction	0	90.11d

a- Calculated from composition and gross heating value.
b- Calculated from speciation.
c- Calculated by Aspen-Advisor software.
d- Calculated from used cooking oil composition.

2.0 Materials and Methods

2.1 Materials, Chemical Reagents and Equipment

These include Waste vegetable oil, Sodium hydroxide, Methanol, Pipette and Pycnometer bottle. Other are Electric weighing balance, Beaker, Measuring cylinder, Magnetic hot plate and Water bath. The used groundnut oil was sourced from local bean-cake sellers at Bosso market, Minna. Nigeria. Aldrich Chemicals Co. Ltd, England, manufactured methanol having a boiling point of 65^0C and 99.5% purity and sodium hydroxide that served as catalyst.

2.2 Experimental Procedure

Using the above materials/apparatus, three samples of the used vegetable oil were put in three different beakers to produce the biodiesel varying temperature, time and quantity of catalyst used using the procedure below. The following physical and chemical properties of the oil were determined:

2.2.1 Characterization of used vegetable oil

Specific gravity

This experiment was carried out in accordance with description reported by Onwuka, (2005). A 50ml pycometer is washed thoroughly with detergent, water and petroleum ether, it is then dried and weighed. The bottle is filled with water and weighed, the bottle is then dried and filled with groundnut oil sample and weighed. The density of a substance is equal to mass of a substance per unit volume of that substance. The temperature at which the density is being measured is known, as density changes with changes in temperature (Ibitoye, 2005).

$$\text{Specific gravity} = \frac{weight\ of\ groundnut\ oil\ (ml)}{weight\ of\ water\ (ml)}$$

$$\text{Density} = \frac{weight\ of\ oil\ (g)}{volume\ of\ oil\ (ml)}$$

Refractory Index:

A few drops of the oil will be placed on the face of the prism of the refractometer and allowed to gently spread close and it will be tightened for sometimes so as to allow for the oil and the prism to attain a steady temperature. The refractive index will be read from the demarcation line after adjusting to where it coincides with diagonal crossing (Ibitoye, 2005).

Acid Value (AN)/Free Fatty Acid (FFA) (ASTM D 664):

The free fatty acid is estimated by titrating 10g of waste vegetable oil against sodium hydroxide (NaOH) using phenolphthalein as indicator (Ibitoye, 2005). The acid value is mg NaOH required for neutralizing the free fatty acids present in one gram of the sample. It is expressed as oleic acid (octadec-9-enoic acid) equivalent. The acid value in mg/NaOH/g oil is gotten by using the equation given in the appendix A.

$$AN = \frac{56.1x\ V\ x\ N}{Woil}$$

where;

V= volume of standard alkali used

N= normality of standard alkali used

W_{oil}= weight of oil used

$$FFA = \frac{AN}{2}$$

Iodine Value (IV):
This is the measure of the degree of unsaturation in a given volume of oil. 0.25g of the oil will be weighed into a glass stopper bottle and 10cm^3 will be added and it will be shaken so as to dissolve the oil. 25cm^3 of iodine monobromide will be added from a burette to stopper and then kept in the dark for exactly 30mins. After 30mins during which iodine absorption must have taken place, 15cm^3 and 1000cm^3 of distilled water will be added. The mixture will be titrated against standard sodium sulphate solution until the colour becomes faint yellow. At this point, 1cm3 of starch solution will be added and titration will be completed and simultaneously, a blank titration will be carried out using the same reagents and distilled water in exactly the calculation but with the oil (Ibitoye, 2005).

$$\text{Iodine Value} = \frac{0.1269 \times (B-A) \times N \times 100}{W_{OIL}}$$

where;

B= volume of standard Na_2CO_3 used in blank titration.
A= volume of standard Na_2CO_3 used in titration with oil.
N= normality of standard Na_2CO_3.
W_{oil}= weight of oil used.

Saponification value
Saponification value is the amount (mg) of alkali required to neutralise definite quantity (1g) of an oil. A known quantity of oil is refluxed with an excess amount of alcoholic KOH. After saponification, the remaining KOH is estimated by titrating it against a standard acid. The saponification value of the groundnut oil was determined in accordance to the experimental procedure reported by Onwuka (2005). The alcoholic KOH is freshly prepared by dissolving KOH pellet in ethanol. 2g of groundnut oil is measured and poured into a conical flask. 25ml of the alcoholic KOH is added to it, a blank is used. The sample is well covered and placed in a steam water bath for 30minutes shaking it periodically, 1ml of phenolphthalein is added to the mixture and titrated against 0.5M HCl to get the end point (Ibitoye, 2005).

$$\text{Saponification value} = \frac{(B-A) \text{x } 28.05}{weight\ of\ groundnut\ sample\ (g)}$$

Peroxide value
The peroxide value of the groundnut oil was determined in accordance to the experimental procedure reported by Onwuka (2005). 1g of groundnut is weighed into a clean drying boiling tube, 1g of powdered potassium iodide and 20ml of solvent mixture (2volume of glacial acetic acid + 1volume of chloroform) is added, the tube is placed in boiling water so that the liquid boils within 30seconds and is also allowed to boil vigorously for not more than 30seconds. The content is quickly poured into a flask containing 20ml of potassium iodide solution; the tube is washed out with 25ml of distilled water and is titrated with 0.002M sodium thiosulphate solution using starch as indicator (Ibitoye, 2005). A blank is also carried out at the same time.

$$\text{Peroxide value} = \frac{T \text{ x M x } 1000}{weight\ of\ sample\ (g)}$$

Filtration
The used vegetable oil collected from the bean-cake fryers was first properly filtered using a filter paper and transferred into a clean beaker so as to remove completely every food particle present in the oil and obtain a very clean, clear and particle free oil which will guarantee a good and acceptable result.

2.2.2 Transesterification Process

Sample 1
1.0g of NaoH crystals was put into a beaker and 100ml of methanol was used to dissolve the NaoH crystals by heating it on a magnetic hot plate with a magnetic stirrer inside the mixture to obtain a meth oxide solution. 100ml of the used vegetable oil was measured and poured into a separate beaker and was purified by heated in a water bath at a temperature of 45 for 60 minutes. 25ml of the meth oxide solution was then mixed with the 100ml of purified oil and the mixture was heated for 30 minutes on the magnetic hot plate with a magnetic stirrer inside the mixture (Schuchardt*et al.,* 1998).

Sample 2
1.5g of NaoH crystals was put into a beaker and 100ml of methanol was used to dissolve the NaoH crystals by heating it on a magnetic hot plate with a magnetic stirrer inside the mixture to obtain a meth oxide solution. 100ml of the used vegetable oil was measured and poured into a separate beaker and was purified by heated in a water bath at a temperature of 65 for 90 minutes remove the free fatty acid content which may alter the result. 25ml of the meth oxide solution was then mixed with the 100ml of purified oil and the mixture was heated for 30 minutes on the magnetic hot plate with a magnetic stirrer inside the mixture (Schuchardt*et al.*, 1998).

Sample 3
2.0g of NaoH crystals was put into a beaker and 100ml of methanol was used to dissolve the NaoH crystals by heating it on a magnetic hot plate with a magnetic stirrer inside the mixture to obtain a meth oxide solution. 100ml of the used vegetable oil was measured and poured into a separate beaker and was purified by heated in a water bath at a temperature of 70 for 120 minutes remove the free fatty acid content which may alter the result. 25ml of the meth oxide solution was then mixed with the 100ml of purified oil and the mixture was heated for 30 minutes on the magnetic hot plate with a magnetic stirrer inside the mixture (Schuchardt*et al.*, 1998).

2.2.4 Settling
Sample 1
The result of the samples were kept in desiccators for 48 hours to allow for separation of the biodiesel from glycerine after which the biodiesel gotten was separated by a decantation process and was washed with water and heated to obtain pure biodiesel.

2.2.5 Analysis
Characterisation of the Biodiesel Produced
Determination of Specific Gravity: ASTM D1298 — Density, Relative Density (Specific Gravity) determination, by Hydrometer Method
This procedure is used to measure of specific gravity of the biodiesels. A clean dry empty 50ml density bottle is to be weighed and the mass recorded as M, it is then filled up with distilled water

and subsequently with the samples. The mass of the bottle and water is taken and recorded as M_1 and that of biodiesel as M_2 respectively hence, the specific gravity is evaluated. This procedure is used to determine the specific gravity of the sample.

Specific gravity (biodiesel produced) = $\frac{m_1 - m}{m_2 - m}$

Determination of Flash Point: ASTM D 93 — Flash-Point by Pensky-Martens Closed Cup Tester:

A sample of the biodiesel is heated in a close vessel and ignited. When the sample burns, the temperature is recorded; the pensky-martens cup tester measures the lowest temperature at which application of the test flame causes the vapour above the sample to ignite. The biodiesel is placed in a cup in such quantity as to just touch the prescribed mark on the interior of the cup. The cover is then fitted onto the position on the cup and Bunsen burner is used to supply heat to the apparatus at a rate of about 5^oC per minute. During heating, the oil is constantly stirred. As the oil approaches its flashing, the injector burner is lighted and injected into the oil container after every 12 second intervals until a distinct flash is observed within the container. The temperature at which the flash occurred is then recorded, it is repeated three times and the average taken (Van Gerpen, 2005).

Determination of cloud point: ASTM D 2500 — Cloud Point of Petroleum Products

A sample of the biodiesel is placed in a test jar to a mark and then placed inside a cooling bath. The temperature at the bottom of the test jar that is the temperature at which the biodiesel starts to form cloud is taken as the cloud point (Van Gerpen, 2005).

Determination of kinematic viscosity:ASTM D 445 — Kinematic Viscosity

A viscometer is inserted into a water bath with a set temperature and left for 30minutes. The sample is added to the viscometer and allowed to remain in the bath as long as it reaches the test thermometer. The sample is allowed to flow freely and the time required for the meniscus to pass from the first to the second timing mark is taken using a stop watch. The procedure is repeated a number of times and the average value are taken which is then multiplied with the viscometer calibration to give the kinematic viscosity (Van Gerpen, 2005).

Determination of pour point: ASTM D 97 — Pour Point of Petroleum Products

A sample of the biodiesel is kept in the freezer to about 50^0C then placed in a heating mantle to melt. The temperature at the bottom of the test jar that is the temperature at which the biodiesel starts to pour is taken as the pour point (Van Gerpen, 2005).

Cetane Number of Diesel Fuel Oil ASTM D 613

Is a measure of the fuel's ignition delay, Higher Cetane numbers indicate shorter times between the injection of the fuel and its ignition. Higher numbers have been associated with reduced engine roughness and with lower starting temperatures for engines (Van Gerpen, 2005).

Acid Number of Petroleum Products by Titration ASTM D 664

The biodiesel sample is measured and poured in a beaker. A neutral solvent (a mixture of petroleum ether and ethanol) is prepared and 50ml of it is taken and poured into the beaker containing the biodiesel. The mixture is stirred vigorously for 30minutes. 0.56g of potassium hydroxide (KOH) pellet is measured and placed in a separate beaker and 0.1M KOH is prepared,

3drops of phenolphthalein indicator is added to the sample and is titrated against 0.1M KOH till the colour change observed turned pink (Van Gerpen, 2005).

3.0 Results and Discussion

3.1 Results

3.1.1 Characterization of used vegetable oil

Table 3 contained the result of the characterization of the used vegetable oil.

Table 3. Characterization of used vegetable oil

Sample name	Used Vegetable oil
Acid value	17.391 mg KOH/g
FFA value	8.70 mg/g
Iodine value	119g
Peroxide value	10
Saponification value	191.388 mg/g
Specific gravity	0.912
Refractive index	1.463

3.1.2 Biodiesel produced

Table 4 contained the result of the quantity of biodiesel produced.

Table 4. Biodiesel produced and its yield

Quantity of oil (ml)	Quantity of catalyst (g)	Temperature (^oC)	Time (Minutes)	Biodiesel produced (ml)	Glycerine produce (ml)
100	0.5	45	60	58	19
100	1.5	65	90	79	19
100	2.0	70	120	70	25

3.1.3 Characterization of Biodiesel Produced

Tables5 to 7 contained the results of the characterization of the produced biodiesel.

Table 5. Characterization of Biodiesel produced (Sample 1)

TEST	**UNIT**	**TEST METHOD**		**LIMIT**	**RESULT**
		IP	ASTM		
Specific gravity	kg/l	160	D1298	0.95 max	0.88
Total sulphur	% wt	107	D4294	0.5max	0.006
Flash point	^oC	54	D93	150 min.	ND
Pour point	^oC	219	D97	70 max	ND
Kinematic viscosity	c.s.t	71	D445	26 max	4.65
Diesel index	^oC	21	-	47 min.	18.0
Cetane number		-	D975	40 min.	52.5
Free Glycerine	%mass	-	-	0.02	0.019
Total Glycerine	%mass	-	-	0.24	0.17

Cloud point	^{o}C	219	D2600	40 max	20
Water by Distillation	%vol.	53	D95	0.5 max	Trace
Acid value	mg KOH/g	65	D108	0.5 max	0.43

Table 6.Characterization of Biodiesel produced (Sample 2)

TEST	UNIT	TEST METHOD		LIMIT	RESULT
		IP	ASTM		
Specific gravity	kg/l	160	D1298	0.95 max	0.89
Total sulphur	% wt	107	D4294	0.5max	0.006
Flash point	^{o}C	54	D93	150 min.	ND
Pour point	^{o}C	219	D97	70 max	ND
Kinematic viscosity	c.s.t	71	D445	26 max	4.65
Diesel index	^{o}C	21	-	47 min.	19.0
Cetane number		-	D975	40 min.	53.5
Free Glycerine	%mass	-	-	0.02	0.019
Total Glycerine	%mass	-	-	0.24	0.18
Cloud point	^{o}C	219	D2600	40 max	20
Water by Distillation	%vol.	53	D95	0.5 max	Trace
Acid value	mg KOH/g	65	D108	0.5 max	0.46

Table 7. Characterization of Biodiesel produced (Sample 3)

TEST	UNIT	TEST METHOD		LIMIT	RESULT
IP	ASTM				
Specific gravity	kg/l	160	D1298	0.95 max	0.88
Total sulphur	% wt	107	D4294	0.5max	0.006
Flash point	^{o}C54	D93	150 min.	ND	
Pour point	^{o}C	219	D97	70 max	ND
Kinematic viscosity	c.s.t	71	D445	26 max	4.65
Diesel index	^{o}C21	-	47 min.	19.0	
Cetane number		-	D975	40 min.	53.1
Free Glycerine	%mass	-	-	0.02	0.019
Total Glycerine	%mass	-	-	0.24	0.17
Cloud point	^{o}C	219	D2600	40 max	20
Water by Distillation	%vol.	53	D95	0.5 max	Trace
Acid value	mg KOH/g	65	D108	0.5 max	0.45

3.2 Discussion

3.3.1Effect of Catalyst concentration on purity

From the three samples of biodiesel produced as seen in the results, the concentrations of catalysts used vary for the three samples with the same quantity of oil. When a little quantity of the catalyst was used for the first sample, it was discovered that the purity of the biodiesel obtained did not conform to the acceptable standard as seen in most literatures and this could prove costly for its use in automobiles using diesel engines. This is because the viscosity of the diesel, cetane rating among other properties is below the recommended value and this could lead to excessive use of the diesel by automobiles and smoky exhaust. This is not advisable as smoky exhaust causes the release of carbon monoxide to the environment, which could prove harmful to the people living in that area and the excessive increase in the cost of maintaining the vehicle for the user (Jose *et al.*, 2005).

3.3.2 Effect of Catalyst Concentration on Yield

From the three samples of biodiesel produced, the yields obtained are of three different volumes despite using the same quantity of oil for the production. The yield of the first sample was the smallest of the three. The third sample with a catalyst concentration of 2.0g and then the second with a catalyst quantity of 1.5 g followed this. The second sample produced more biodiesel because of the reaction ratio of the oil sample to the catalyst. From this, It can be deduced that a biodiesel produced using this ratio will yield more product and less glycerine (Jose *et al.*, 2005).

3.3.3 Effect of Reaction Time on Purity

From the results obtained, the reaction time of 90 minutes produced the biodiesel that is in its purest state than the other two at 60minutes and 120 minutes. This implies that at a lower reaction or higher reaction time than 90 minutes, the biodiesel produced may likely be of low quality as well as contain some form of impurities. This can be checked by ensuring that diesel produced at acceptable reaction ratio is allowed to completely react at corresponding time, which will enhance the purity of the diesel, produced (Jose *et al.*, 2005).

3.3.4 Effect of Reaction Time on Yield

The result obtained shows that the highest quantity of biodiesel produced was at a reaction time of 90 minutes. This implies that the biodiesel produced at 60 minutes and 120 minutes have lower yield and which suggest that with a reaction time of 90minutes, the second sample produced more biodiesel with good combustion properties and less glycerine than the other two (Jose *et al.*, 2005).

4.0 Conclusions and Recommendations

4.1 CONCLUSIONS

The biodiesel produced at a temperature of 65^{o}c, time of heating as 90minutes and quantity of catalyst as 1.5g (NaOH) was found to be of higher quality and generated more yield than the rest with a good reaction ratio(oil : catalyst). From this, it can be concluded that producing biodiesel using the above-mentioned ratio, will result in high yield of quality biodiesel using used vegetable oil as feedstock.

4.2 RECOMMENDATIONS

a. The use of renewable energy should be encouraged due to its environmental friendly nature and reduce over-dependence on energy from fossil fuel.

b. In further research work, the free fatty acid present in the used vegetable oil should be removed so as to obtain a higher yield of biodiesel as its presence affects the yield of biodiesel.
c. The single step transesterification method should be used in subsequent research work on biodiesel production because it safes time, is reduces production cost, better understood for first time researchers and produces pure biodiesel with good combustion characteristics.

REFERENCES

Demirbas A. (2008): Relationships Derived from Physical Properties of Vegetable Oil and Biodiesel fuel, Fuel 87: 1743-1748.

Felizardo P., Correia M., Raposo I., Mendes J., Berkemeier R. and J. Bordado (2006): Production of Biodiesel from Waste Frying Oil, Waste Management. 26: 487-494.

Fukuda H., Kondo A.and H. Noda (2001): Review Biodiesel Fuel Production by Transesterification of Oils,*Journal of Bioscience and Bioengineering*92 : 405-416.

IbitoyeA.A, (2005): Analytical chemist/consultant. Department of crop, soil and pest management, Federal university of technology Akure, Nigeria.pp 14-21.

Lakshmi G.N., RamadhasA.S., Nallusamy N., and P. Sakthivel(2010): Relationships among the physical properties of biodiesel and engine fuel system design requirement, *International Journal of Energy and Environment*, 1(5): 919-926.

Jose M. Encinar, Juan F. Gonzalez and A. Rodriguez- Reinares (2005): Biodiesel from Used Frying Oil, Variables affecting the Yields and Characteristics of the Biodiesel, Industrialand Engineering Chemistry Research,44:5491- 5499

Meher L., Vidya S., and S.Naik (2006): Technical Aspects of Biodiesel Production by Transesterification- a review, Renewable and sustainable Energy reviews 10: 248–268.

Onwuka B. (2005): Food Analysis and Instrumentation Theory and Practice, Naphtali prints, Lagos, Nigeria. Pp 140-150.

Ramadhas A., Jayaraj S., and C.Muraleedharan (2005): Biodiesel Production from High FFARubber Seed Oil, Fuel 84:335-340.

RamadhasA.S., Muraleedharan C. and S.Jayaraj (2009): Biodiesel Production Technologies and Substrates. Hand Book of Plant Based Biofuels. Ed. Ashok Pandey, CRC Press Taylors& Francis Group, USA.

Schuchardt U., Sercheli R., and R. M. Vargas (1998): Transesterificationof Vegetable Oils: *aReview Journal of the Brazilian Chemical Society* 9: 199-210

Van Gerpen J. (2005): Biodiesel processing and production. Fuel Processing Technology 86:1097-1107

Magín L., José M.H, Lisbeth L. L., García-Contreras R. and B. Yolanda(2008): Effect of the Alcohol Type, Used in the Production of waste cooking oil Biodiesel on Diesel Performance and Emissions, *Science direct journal-Fuel*, 87 (15-16) : 3161-3169.

APPENDIX



Plate 1: Biodiesel using NaOH catalysts



Plate 2: Biodiesel ester and glycerine layer



Plate 3: Biodiesel washing using distilled water



Plate 4: Glass reactor with heating plate and magnetic stirrer

COMPARATIVE STUDY OF THE EFFECTS OF TREATMENT TECHNIQUES ON THE MECHANICAL PROPERTIES OF KENAF (*HIBISCUS CANABINUS)* FIBRE REINFORCED BRAKE PADS

Namessan, N.O[1]., J.N. Maduako[2]., S.A Iya[2] and B. Aliyu[2]

[1]Department of Agronomy, Taraba State University,

P.M.B 1167 Jalingo, Nigeria

+234 (0) 802 368 0028

Email address: naneekee@yahoo.com

[2]Department of Agricultural and Environmental Engineering

Modibbo Adama University of Technology, Yola-Nigeria

ABSTRACT

Asbestos fibre has been used as the traditional base material in brake pads manufacture, but due to its health hazard, non-renewability, cost, non-biodegradability and difficulty in processing, its replacement has been sought. This paper reports the effects of some fibre treatment techniques namely: mercerization, acetylation and semi-carbonisation on the performance of Kenaf fibres. The treated kenaf fibres which are considered biodegradable, cost effective, renewable and user friendly have been used as a possible base friction material for brake pad production. Results indicated that they all the four kenaf brake pad samples behave differently during performance evaluation. Of all the samples studied, Mercerized kenaf brake pad samples exhibited high values of Rockwell hardness of 101$\pm$1.379 HR and an Impact strength of 20.86$\pm$0.704KJ/cm^2 on the average. Compressibility test indicated that Acetylated fibre based samples also show high compressive strength of 0.86$\pm$0.058KN/mm^2 as compared to Crude, mercerised and semi-carbonised fibre based kenaf brake pads.

Keywords: treatment techniques, kenaf fibre, comparative study, brake pads

1. Introduction

Brake pad for an automotive brake system is friction complex composites because they contain numerous ingredients that are diverse in physical, mechanical and chemical properties. These brake pads or friction composites comprise many disparate ingredients such as binders, fibres and fillers. According to Marthur *et al (*2004), asbestos fibres, which occurred naturally as mineral, have been used as traditional fibrous ingredient to reinforce the constituents in the friction material or to provide mechanical strength and also to inhibit catastrophic failure of the structure. However, due to its non-biodegradability, non-renewability, difficulty in processing, high cost, high density and most especially its risk of causing cancer, asbestos – based friction materials were banned and the search for safer and cheaper alternative sources started as reported by NICNAS (1999) and Warren (1992). Several treatment techniques intended to improve the natural fibre-matrix adhesion in brake pad composites were reported in literature. Some of the techniques considered in this paper are mercerisation, acetylation and semi-carbonisation of kenaf fibre as compared to using the crude. The objectives of this study is to compare the effects of these fibre treatment techniques on the mechanical properties such as Rockwell Hardness(HR), Impact Strength (JK/cm^2) and Compressive Strength (KN/mm^2) of Kenaf Brake Pad samples.

2. Materials and Methods

2.1 Materials for kenaf brake pad production

The materials used in this study include binder or polyester, fillers (rubber crumbs, fine grain iron filings, graphites, barium sulphate), rolls of decorticated kenaf fibre, sodium hydroxide, ammonium oxalate, hydrochloric acid, hydrogen peroxide, tools and equipment include; furnace, oven, drier, hardness tester, compression moulding rig, friction test rig, impact tested, digitizer, camera fitted light microscope, microtome, stop watch, weighing balance and intsrone machine.

2.1.1 Binder

The Unsaturated Polyester Binder that was used was obtained from the Northern Scientific Laboratory Located here in Yola.Ten litres of this binder were purchased for the purpose of this research.

2.1.2 Fillers

2.1.2.1 Rubber crumbs

These are the other black particles that are seen in commercial brake pads. They are produced from scrap rubber from used tires of 50 μm and are relatively inexpensive. The low specific weight of rubber was an advantage in the final product. In this work 500 g of rubber crumbs was ground to 0.5 mm particle size and was used.

2.1.2.2 Fine grained metal iron

Fine grain metal iron or iron powder was used in this research as an abrasive. About 1.5 kg of fine-grain metal iron was sieved which was obtained as waste from Machine Shops in Jimeta, Yola. This was sieved into fine grain of 2 μm size

2.1.2.3 Graphite

Graphite occurs naturally in places like Gayama village in Taraba State, Nigeria. From this village, which is about 289 km from the state capital, Jalingo, 1.2 kg of graphite stone was mined or dug from the deposit for the purpose of this study. Thereafter, it was milled and the product, which is a fine powder, was sieved through a 200 mesh (75 um).

2.1.2.4 Barium Sulphate

Like graphite, Barium Sulphate also called barite was obtained locally from the mines at Lau village of Taraba State. This filler was ground into powder by means of a plate mill; thereafter it was sieved through a 345 mesh (5 μm). A Total of 1.5 kg of this material was used in this study.

2.1.3 Kenaf fibre

Ten rolls of decorticated Kenaf fibre were used in this study, it was procured from Jimeta Market, Yola. These fibres have been decorticated, dried and packed in form of rolls. The material represents a matured fibre and the best of its type available in the locality. These fibres were purified and transformed into better fibre through some innovative chemical treatments discussed previously. Using a plate mill, I kg each of the four fibre Treatments was ground and sieved into an average length of 2 - 4 mm and an average diameter of 12 μm. According to Jang *et al* (2001and 2005); Marthur *et al* (2004), 10 % - 20% fibre reinforcement was used in brake padding

(Pre trials to determine the fibre volume fraction were also carried out). Thereafter, 15% by weight of kenaf fibre was considered adequate for reinforcement in this study.

2.2 Methods

2.2.1 Surface modification by semi – carbonization or heat treatment

Crude fibre having been retted and bleached was semi-carbonised using a laboratory oven as shown on Figure 5a, b, and c. An equal weight of 0.300 g of the above kenaf fibre sample was weighed. And using a heating rate of 2.21 ^{0}C/min, each batch was heated to temperatures of 100^{0}C 150^{0}C, 200^{0}C, 250^{0}c and 300^{0}C respectively. It was then soaked for 5 mins at each temperature threshold as was done by Rowell *etal* (1995).

2.2.2 Production of kenaf brake pads

2.2.2.1 Experimental Design

The experiments were of the randomised 1 x 3 x 3 factorial design for four different types of kenaf fibre at 15 % weight each.. Table 1 shows the outline of the experimental design for the four types of kenaf fibers with three levels of polyester binder and filler.
Main treatment: **T_1**(Untreated fibre); **T_1** (Mercerized fibre); **T_1** (Acetylated fibre); T_1 (Semi – Carbonized fibre) at 15 % weight each. **Sub-treatmen**ts: **S_1** (15 % polyester (Binder)); **S_2** (20% polyester); **S_3**(25% polyester), then filler at **R_1** (60 %), **R_2** (65 %), and **R_3**(70 %) by weight .

Treatment combination = for the four types of fiber treatments = 1 Level of fibre × three levels of binder (Polyester) x three levels of Filler = 1 x 3 x 3 = 9 (T1S1R1, T1S1R2, T1S1R3, T1S2R1, T1S2R2, T1S2R3, T1S3R1, T1S3R2 and T1S3R3)

Total experiments conducted= 9 treatments x 4 Fibre Types × 5 replications = 108 experiments.

T,S and **R** were mere letters chosen to represent fibre treatment, binder (polyester) and Filler, respectively The numbers 1, 2, 3 were used to denote the levels of the factors. This exercise was done this way for convenience only.

Table 1 Experimental design for kenaf brake pad samples

		Treatment			
S/N	Sample code	Kenaf FibreType (1 level)	Polyester (3 levels)	Filler (3 levels)	Replications
1.	T1S1R1	1	1	1	5
2.	T1S1R2	1	1	2	5
3.	T1S1R3	1	1	3	5
4.	T1S2R1	1	2	1	5

5.	T1S2R2	1	2	2	5
6.	T1S2R3	1	2	3	5
7.	T1S3R1	1	3	1	5
8.	T1S3R2	1	3	2	5
9.	T1S3R3	1	3	3	5
10	Control (commercial sample)	NA	NA	NA	NA

NA = Not Available

1 Kg of rubber crumbs, 1 Kg of iron filings, 1 Kg of barium sulphate and 1 Kg graphite to give 4 Kg of Fillers.

Total Raw Materials used in this study = 100g x 1 treatment x 5 replications = 500g

Where the treatment combination does not give exactly 500g, calcium carbonate was used as a space filler to adjust the remaining percentage during replications as was done by Marthur *et al* (2004). Then the materials used in this study is approximately, 500g x 9 Treatments x 4 Fibre Types = 18,000g

2.2.2.2 Mixing of raw materials

In order to assist fiber dispersion, kenaf fibres were fiberized in a double-bladed kitchen blender for 8 mins. The fiberized kenaf fibers were dried at 60^0C for 24 h and stored in a desiccator, prior to compounding. A total of 9 samples with five replicates for each formulation of the four fibre treatments were mixed batch by batch.

The mixing was done at a temperature of 38^0C, mixing time of 5 mins, and rotor speed of 600 rpm as was done by Jang *etal* (2001). The first treatment mixing was carried out in this manner: the binder resin (unsaturated polyester (15 % of the Total weight) was first added inside the mixing chamber then another 15 % by weight of the fibre type was added, and finally 70 % by weight of the last component (filler) was also added. The mixer containing 100 g of kenaf fibre, polyester and filler was started and run for 5 mins until the three components were mixed. Thereafter the mixed material was removed for the next process.

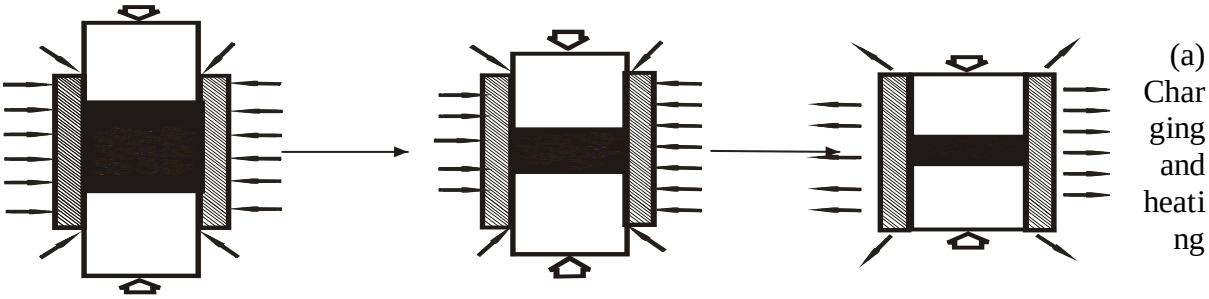
2.2.2.3 Compression moulding

The mixed material was molded on a Hydraulic press into pads with dimensions of 6 cm x 4 cm x 2 cm. The mold was first preheated to raise the temperature to175 ^{0}C. As shown in Figure 1 and Figure 2, the mixed material was then placed in the mould and heated for 1 min under a constant pressure of 32.5 MPa; thereafter the moulded material was removed and cooled at room temperature for 8 mins as outlined on Figure 2a-d.



Figure 1 Compression moulding process using the CMR Equipment

The pressed samples were then cured in an Oven for 8h, thereafter it was finished and prepared for performance properties (Booker., 1992 and Jang *etal.*, 2001)



(a) Charging and heating

b) Heating andmoulding

(c) Cooling

brake pad sample

(d) Demoulding

Figure.2 a, b, c and d. Compression Molding process for kenaf brake pad (Namessan,2008)

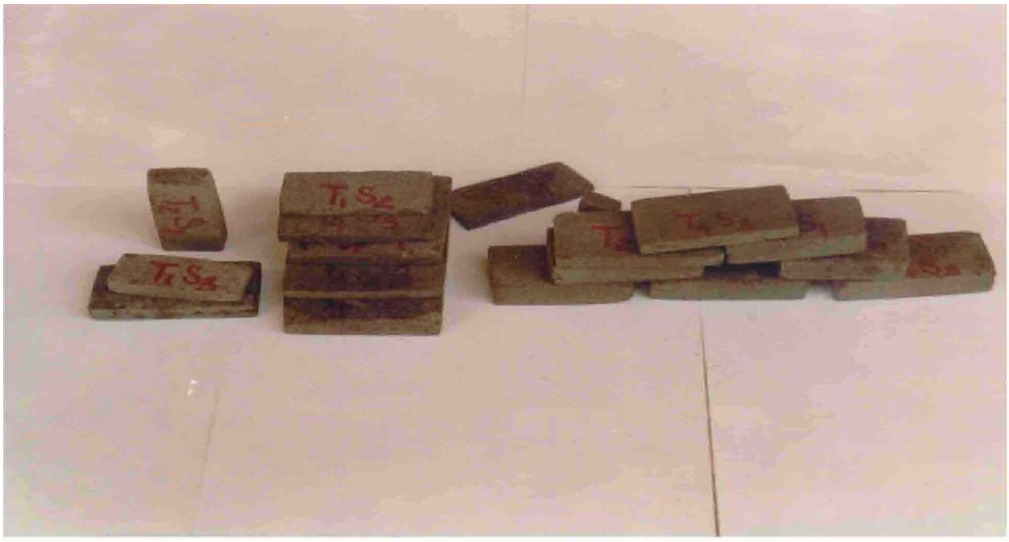


Plate 1 Kenaf brake pad samples

3.3.2 Testing for mechanical properties of kenaf brake pads

The mechanical properties investigated in this research for the purpose of characterising the brake pads were hardness and impact resistance.

3.2.1 Rockwell hardness of brake pads

Rockwell hardness measurements were performed according to ASTM D2240-77 (ASTM 1999). The Rockwell hardness tester consists of a Pressure foot, an indenture, and an indicating device. The test was carried out by first placing a specimen on a hard, flat surface. The pressure foot of the instrument was pressed on to the specimen, making sure that it was parallel to the surface of the specimen of 2 cm x 2 cm x 4 cm. The Rockwell hardness was read within 1 s after the pressure foot was in firm contact with the specimen. Each specimen was subjected to five Rockwell hardness readings; the results obtained from this experiment was statistically analysed.

3.3.2.2 Impact resistance of kenaf brake pads

The Impact properties of the polymeric materials are directly related to the overall toughness of the material. The impact strength test was developed to overcome the deficiencies of flexural tests. Impact energy is the energy required to break a standard impact specimen in tension by a single swing of a standard calibrated pendulum under a set of standard conditions. The impact strength test was conducted according to ASTM (1995) which was briefly stated as follows, The specimen was clamped into the impact tester fixture with the notched side facing the striking edge of the pendulum. The pendulum was raised and released and the impact energy was determined, recorded for all the specimens in all group of brake pad samples and their average was calculated and recorded.

4. Results and Discussion

4.1 Evaluation for mechanical properties of kenaf brake pads reinforced with crude kenaf fibre.

The results of the evaluation of mechanical properties of kenaf brake pads reinforced with crude fibres is as presented on Table 2.

Table 2: Evaluated mechanical properties of crude samples

		Treatment			Mechanical properties		
S/N	Sample code	Crude Fibre (1 level)	Polyester (3 levels)	Filler (3 levels)	Rockwell Hardness HR	Impact strength KJ/cm^2	Compressive strength KN/mm^2
1.	T1S1R1	1	1	1	55.628± 1.293	4.966± 0.180	0.616± 0.045
2.	T1S1R2	1	1	2	54.734 ± 1.778	6.890± 0.310	0.612± 0.033
3.	T1S1R3	1	1	3	55.810 ± 2.072	7.312± 0.308	0.530± 0.038
4.	T1S2R1	1	2	1	57.096 ± 1.549	10.030± 0.320	0.572± 0.058
5.	T1S2R2	1	2	2	58.218 ± 0.845	14.452± 0.391	0.530± 0.054
6.	T1S2R3	1	2	3	67.498 ± 1.885	15.558± 0.508	0.566± 0.028
7.	T1S3R1	1	3	1	67.498 ± 1.885	16.010± 0.419	0.466± 0.025
8.	T1S3R2	1	3	2	59.452 ± 1.254	17.140± 0.337	0.454± 0.027
9.	T1S3R3	1	3	3	60.070 ± 0.879	18.272± 0.439	0.454± 0.011
10	Control	NA	NA	NA	110.60 ± 4.04	14.53 ± 0.81	0.395 ± 0.021

NA = Not Available

From Table 2, it is clear that the average values of Rockwell Hardness (HR) in crude samples which ranges from 55.628 HR in T1S3R3 sample code to as high as 67.498 HR in T1S2R3. Impact resistance (kN/cm^2) also range between 4.966 in T1S1R1 to a much higher average value of 18.272 in T1S3R3. The same trend follows in Compressibility (KN/mm^2) where highest value 0.616 occurred in T1S1R1 and T1S3R3 having the lowest value of 0.454 KN/mm^2.

4.2 Evaluation for mechanical properties of kenaf brake pads reinforced with mercerised kenaf fibre.

The results of the performance evaluation of mercerized kenaf brake pad samples is as presented on Table 3 below.

Table 3: Evaluated mechanical properties of brake pads reinforced with Mercerised kenaf fibre

		Treatment			Mechanical properties		
S/N	Sample code	Mercerised Fibre (1 level)	Polyester (3 levels)	Filler (3 levels)	Rockwell Hardness HR	Impact strength KJ/cm^2	Compressive strength KN/mm^2
1.	T1S1R1	1	1	1	76.154 ± 0.640	10.348± 0.588	0.806 ± 0.061
2.	T1S1R2	1	1	2	75.010± 0.402	12.014 ± 0.268	0.904 ± 0.041
3.	T1S1R3	1	1	3	73.466± 0.538	12.984 ± 0.525	0.906 ± 0.039
4.	T1S2R1	1	2	1	99.822± 4.738	19.462 ± 0.433	0.454 ± 0.036
5.	T1S2R2	1	2	2	101.866 ± 1.379	20.862 ± 0.704	0.482 ± 0.034
6.	T1S2R3	1	2	3	96.870 ± 0.838	22.410 ± 0.708	0.536 ± 0.052
7.	T1S3R1	1	3	1	90.650 ± 0.458	24.326 ± 0.452	0.598 ± 0.025
8.	T1S3R2	1	3	2	91.130 ± 0.894	16.200 ± 0.570	0.622 ± 0.025
9.	T1S3R3	1	3	3	85.464 ± 0.412	15.332 ± 0.561	0.696 ± 0.031
10	Control	NA	NA	NA	110.60 ± 4.04	14.53 ± 0.81	0.395 ± 0.021

NA = Not Available

From Table 3, one can observe that the average values of Rockwell hardness (HR) in mercerised samples ranges from 76.154 HR in T1S1R1 sample code to as high as 101.866 HR in T1S2R2. Impact resistance (kN/cm^2) also range between 10.348 in T1S1R1 to a much higher average value of 24.326 in T1S3R1. Compressibility (KN/mm^2) of mercerised kenaf brake pads have the highest value of 0.906 in T1S1R3 which occurred and T1S2R1 having the lowest value of 0.454.

4.3 Evaluation for mechanical properties of kenaf brake pads reinforced with acetylated kenaf fibre.

Table 4 shows the evaluated mechanical properties of brake pads reinforced with Acetylated kenaf fibre. The average values of Rockwell Hardness (HR) of acetylated samples

range from 67.376 HR in T1S1R1 sample code to as high as 74.112 HR in T1S3R2. Impact resistance (kJ/cm^2) also range between 8.176 in T1S3R1 to a much higher average value of 21.526 in T1S1R1.And in Compressibility (KN/mm^2), T1S1R3 has highest value 0.866 KN/mm^2 with the lowest value occurring in T1S3R1(0.466 KN/mm^2) as shown on Table 4.

Table 4: Evaluated mechanical properties of brake pads reinforced with Acetylated kenaf fibre

		Treatment			**Mechanical properties**		
S/N	Sample code	Acetylated Fibre (1 level)	Polyester (3 levels)	Filler (3 levels)	Rockwell Hardness HR	Impact strength KJ/cm^2	Compressive strength KN/mm2
1.	T1S1R1	1	1	1	67.376 ± 1.471	21.526± 0.924	0.856± 0.058
2.	T1S1R2	1	1	2	66.504 ± 2.673	21.060± 0.806	0.864± 0.049
3.	T1S1R3	1	1	3	69.162± 1.224	20.890± 0.071	0.866± 0.130
4.	T1S2R1	1	2	1	70.306 ± 0.671	21.302± 0.418	0.672± 0.103
5.	T1S2R2	1	2	2	72.682 ± 0.961	18.292± 0.504	0.580± 0.075
6.	T1S2R3	1	2	3	71.428 ± 1.065	16.244± 0.502	0.566± 0.063
7.	T1S3R1	1	3	1	67.740 ± 4.490	8.176 ± 4.248	0.466± 0.008
8.	T1S3R2	1	3	2	74.112 ± 0.752	12.072± 0.215	0.540± 0.039
9.	T1S3R3	1	3	3	72.262 ± 0.455	14.850±0.375	0.508± 0.052
10	Control	NA	NA	NA	110.60 ± 4.04	14.53 ± 0.81	0.395 ± 0.021

NA = Not Available

4.4 Evaluation for mechanical properties of kenaf brake pads reinforced with semi-carbonised kenaf fibre.

The results of evaluation of mechanical properties of brake pads reinforced with Semi-carbonized kenaf fibre are presented on Table 5 below.

Table 5: Evaluated mechanical properties of brake pads reinforced with Semi-carbonised fibres

	Treatment				Mechanical properties		
S/N	Sample code	Semi-carbonised Fibre (1 level)	Polyester (3 levels)	Filler (3 levels)	Rockwell Hardness HR	Impact strength KJ/cm^2	Compressive strength KN/mm^2
1.	T1S1R1	1	1	1	87.184±0.757	20.488 ± 0.835	0.510± 0.012
2.	T1S1R2	1	1	2	86.580± 0.740	19.868 ± 0.625	0.476± 0.005
3.	T1S1R3	1	1	3	86.492±1.349	18.890 ± 0.521	0.514± 0.005
4.	T1S2R1	1	2	1	90.600±0.798	14.434 ± 0.701	0.472± 0.016
5.	T1S2R2	1	2	2	90.448± 1.147	14.884 ± 0.842	0.530± 0.007
6.	T1S2R3	1	2	3	90.314± 0.546	14.618 ± 0.631	0.554± 0.008
7.	T1S3R1	1	3	1	74.288± 0.686	14.062 ± 0.501	0.532± 0.004
8.	T1S3R2	1	3	2	73.330± 0.565	14.522 ± 0.952	0.516± 0.015
9.	T1S3R3	1	3	3	71.822± 0.949	14.872 ± 0.414	0.526± 0.005
10	Control	NA	NA	NA	110.60 ± 4.04	14.53 ± 0.81	0.395 ± 0.021

NA = Not Available

From the Table above, the average values of Rockwell Hardness (HR) in semi-carbonised samples which ranges from71.822 HR in T1S3R3 sample code to as high as 90.600 HR in T1S2R1. Impact resistance (kJ/cm^2) also range from14.062 in T1S3R1 to a much higher average value of 20.488 KJ/cm^2 in T1S1R1. The same trend follows in Compressibility (KN/mm^2) where the highest value of 0.554 KN/mm^2 occurred in T1S2R3 and T1S2R1 having the lowest value of 0.472 KN/mm^2

5. CONCLUSION

From the results obtained it is clear that Mercerised kenaf brake pad samples have high hardness with an average value of 101HR. this means that this particular treatment technique increases the hardness property of brake pads. From literature, the harder the brake material the faster the brake discs wear.

REFERENCES

ASTM, (1999) ASTM Standard D570-99: Standard Test Method for Water Absorption of Plastics. American Society forTesting and Materials Standards 08 (01)1271-1285.

Booker, B.U(1992). Compression moulding method of making brake Linings. US Patent 5156787, United States patent and trademark office. pp 123-127

Jang, H., Lee, J.S. and Fash, J.W (2001). compositional effects of the brake friction Material on creep groans phenomena. Journal of wear. 251 (14)1477 – 1483.

Mathur, R.B; P. Thiyagarajan and T. L. Dhami (2004): Controlling the Hardness and Tribological Behaviour of Non-asbestos Brake Lining Materials for Automobiles. Journal of Carbon Science. 5 No. (1): 6-11

Namessan, N.O (2008): Use of kenaf (hibiscus canabinus) fibre as a base friction material in the production of automotive brake pads.Unpublished Ph.D thesis submitted to the Department of Agricultural and Environmental Engineering, Federal University of Technology, Yola

National industrialChemical Notification and Assessment Scheme for asbestos, NICNAS (1999). Priority Existing chemical Report 9, Common Wealth of Austrialia, P. 8

Rowell, R.M., Kawai, S. and M. Inoue. (1995). Dimensionally Stabilized, Very Low Density Fiberboard. Wood and Fiber Science, Vol. 27, No. 4, pp. 428-436.

Ugheoke, B.I; E.O Onche; N.O Namessan and G.A Asikpo (2006). Property Optimizationof Kaolin – Husk Insulating Fire – Bricks. Leonardo Electronic Journal of Practices and Technologies, 9 (34):167-177.

Warren, R. (1992). ceramic- matrix composite, UK asbestos ban in Journal of Sealing technology.72(12):16.