# RIVERS STATE UNIVERSITY, PORT HARCOURT

# PLANT BREEDING SCIENCE: ANCIENT AND MODERN

AN INAUGURAL LECTURE

By


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# Dedication

To my beloved parents, Elder Ezekiel Obuange Ogburia (late) and Mrs. Nnwereocha Ogburia, nee Obua (late) for my principled, disciplined and self-reliance upbringing; Rivers State Government (RVSG) and Shell Petroleum Development Company (SPDC) for separately and collectively sponsoring me through Secondary Education Scholarships from class 2, now JSS 2 to class 5 now SS 3; Bureau for External Aid (BEA) of the Federal Government of Nigeria (FGN) and the Government of Japan (*Monbusho*) for Fellowship awards throughout my Tertiary Education.

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Ladies and Gentlemen

## 1.0 PREAMBLE

I am indeed very humbled to stand before you this evening to deliver my inaugural lecture as a Professor of Plant Genetics of this great University. May I use this chance to inform this August gathering that my promotion to the Professorial rank would have come in 2003 but was denied simply because the powers that be thought I was too young to become one of them (probably because of my personal stylish haircuts and clean shaves which portrayed me as a youth) even though I had all the requirements to be promoted to the rank of Professor. I was rather promoted to the rank of a Reader in October, 2003 thus making me one of those who were promoted to Readership rank from Senior Lectureship as against Professorship which had prevailed until I was involved! However, armed with the information, that I was too young then, I started growing and tendering and if you like, *breeding my beards* until it turned grey as you can see it today. I was eventually promoted in 2006 at the age of

45 and exactly 10 years after earning my Ph.D. having graduated in 1996 and 9 years after joining the University, having been employed in September 23, 1997 and this launched me into prominence, thus making me the first Professor of Plant Genetics of this University, first resident Professor in my community, Elele Town and one of the youngest in Ikwerre Kingdom then. My promotion to the Professorial cadre also humbled me beyond words till now that I am standing before all of you to deliver this Inaugural lecture as some people think of me of *knowing it all about almost everything* which of course can never be correct. In fact I still learn everyday especially from my students and senior colleagues in the profession and from elsewhere too. For me, a day is lost and wasted if I learnt nothing new that particular day.

This is not just an Inaugural lecture but the 49th and also my 11th year Anniversary as a Professor of our prestigious Rivers State University (RSU). Coincidentally too, it is special in a way to me because it is coming to pass in my 56th Birthday being the first child of the $F_1$ progenies of my dear parents, born on 5th October, 1961.

I would define Inaugural lecture as a simplified sequential narrative of a Professor's scientific research experience in his discipline. Inaugural lectures are delivered by Professors only and it is an opportunity to tell the wide world in simple terms what the Professor professes in his chosen discipline, shares his past academic research experiences, contributions to the body of knowledge and highlight future challenges. In other words, we would be sharing what, how and why I am a Professor of this great University and why I would have been one in any other reputable University in the world. I am happy that the Vice Chancellor has given me this chance to do just that as I am intellectually fulfilled in doing so today. Thank you, Mr. Vice Chancellor. What we are witnessing today would have been several (may be 5 or more years ago) but for the protracted RSU





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ASUU – RVSG strike of 2012-2015 under the infamous and defunct administration of Ex-Governor Rotimi Chibuike Amaechi of Rivers State in one hand and my unfortunate abduction by kidnappers on January 17, 2016 followed by my release 5 days after, the consequent long debriefing, treatment and recuperation in hospital in the other. In all of these, I give God all the Glory and Adoration as I stand on my feet alive before our August guests to deliver the 49th Inaugural lecture of this great citadel of learning. It is better late than the late as there is yet no loss! Praise God!

## 1.2 Educational and Agricultural Passion Pathways

My passion pathways to Education and Agricultural Science started as a teenager of a humble and modest farming family of seven (7) in my community, Elele in Ikwerre Local Government Area of River State. During my Primary Education after the Nigerian Civil War in 1970, precisely in primary 3, using a disused chewing stick as brush in black paint from a left-over black paint tin, I consciously and from just nowhere inscribed, ***Dr. PALIPA*** on my school-box made of scrap aluminium sheets with very tiny hinges and staple for small padlock. That name sparked me for academic competition for excellence among my peers in class to the extent of motivating me in making sure that my name was always on the ***Honours Board*** of every Friday's class tests either as the 1st, 2nd or 3rd position pupil. That name became my nickname even up to date by my classmates and close associates.

As years rolled-by I would accompany my illiterate peasant farming parents to the farm and participated in any traditional farming operation of the day which included under-brushing (*cutting – of – bush*) of the vegetation, bush burning, packing of burnt stems as fire-woods (and in the process looked like

masquerade because of charcoal powder stains all over my body, including my face), planting of crop plants like Maize, Vegetables (*Ugu* (Telfeiria), Pepper, Okro, Melon), Yams, Cocoyams, Cassava, etc., manual weeding and tendering of the planted crops up until maturity and harvesting. My late father who was also a lucky hunter in his time, would usually dress in his coverall and shoes made from disused motor tyre and go hunting at night armed with his locally fabricated single-barreled dane gun and head-lamp for wild life like Antelopes (*Cephalophus niger*), Porcupines (*Atherurus africanus*), Grasscuters or Cane Rats (*Thryonomys swinderianus*), Pouched Rats or locally called Rabbits (*Cricetomys emini*) or Eyi in my village. Proceeds from the sale of excesses of both their farm harvests and some of these hunted down wild animals were used to pay my school fees up till class 2 (now JSS 2). However, it would be important to state that the old single-barreled dane gun is still preserved today as an antiquity and as the remaining relics of poverty in our household for future generations ($F_n$) of the Ogburia family, just to remind them of that rather dark chapter of our family history.

Upon admission as a boarding student to the famous County Grammar School, Ikwerre/Etche *(COGRAMSIE VARSITY)* – a foremost and renowned Secondary School, East of the Niger in 1974, my passion for Agricultural Science grew stronger especially when we were made to cultivate and own ridges with chosen crops planted in them in the School farm. These ridges were regularly monitored and inspected by our Agricultural Science Tutor and at the end of the cropping season, assessed and grades awarded. Inside me, I had always wondered and thought how these small seeds and cuttings used as planting materials or propagules germinated and or





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sprouted to become big plants of harvestable with tangible edible yields. Little did I know then of the mechanisms of nutrient uptake, growth, pollination, embryogenesis, seed-set, photosynthesis, translocation of synthates and dry matter accumulation processes during plants' life.

Having graduated from Cogramsie Varsity (with WASCE) in 1979 with aggregate 18 points, Division 1, admission and enrollment into any good University starred me in the face. Poor parentage became even a huge problem and I was unable to buy JAMB form as a consequence. However, not deterred, I sought for and secured a job as an Auxillary Tutor from the Rivers State Schools Management Board to enable me save some funds to buy JAMB form to proceed to University. Meanwhile, Newspapers became my companion, looking for University Admission and Scholarships Advertorials and I applied for it whenever there was one. Infact, there were many such advertisements then and I kept applying for as many as came my way, forgetting some in the process. In 1981, God showed up on my lane, showering me with His Abundance in Glory! A bossom friend of mine, Mr. Charlse Okpara from a neighboring Community, Omerelu alighted from a bus to make way for a passenger to drop off, right in front of our father's family compound which is by the Highway, and I quickly inquired, shouting, Charlie, what's up? He replied, saying that he was returning from Rivers State Scholarship Board, Moscow Road, Port-Harcourt where he had gone to check his name on the list of successful applicants for Scholarship abroad. Really! Was your name there? I retorted. No! He replied. Did you see my name? I queried. No, I actually don't know because I couldn't remember your surname, he replied me. I hurriedly requested for transport fare from my late Dad who obliged me and

within 60 minutes I was at the Rivers State Scholarship Board, Moscow Road, Port-Harcourt. Going through the pasted list of 30 successful applicants, my name; Michael Nnah Ogburia was no. 29 (second to the last!). Incidentally, however, final selection interview at the then Soviet Embassy, Victoria Island, Lagos was scheduled to be held the next day. An earlier telegramme sent to me detailing this information was never received until after the final selection interview was conducted. I took the night luxurious bus that same day and arrived Lagos the next morning, early enough to navigate my way through the busy Lagos roads and streets to locate the embassy. At the rigorous and highly competitive final selection interview, I was finally asked to choose between reading Economics and Agricultural Science for a University Education abroad, I rightly chose to major in the latter with specialization in Agronomy & Breeding in the Tashkent Agricultural Institute, now Tashkent Agricultural University, Tashkent, Uzbekistan in the former Union of Soviet Socialist Republics (USSR). I graduated with a Masters' Degree (M. Sc.) in 1987.

Having concluded the National Youth Service Corps (NYSC) in my parent Department of Crop/Soil Science, Faculty of Agriculture of this University in 1988, I secured two (2) appointments; one (1) as an Assistant Lecturer with the then Rivers State College of Education (RSCOE), now Ignatius Ajuru University of Education (IAUOE) with N600.00 (Six hundred Naira) only as salary per month; and two(2) appointed as a Research Associate in 1989 by the International Institute of Tropical Agriculture (IITA), Ibadan, Oyo State with N1, 200.00 (One thousand and two hundred naira) only as monthly salary. I opted for the latter for obvious reason and was posted to its High-rainfall Station, Onne,





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Rivers State, under Professor Rony Swennen – a Belgian Geneticist and Breeder and late Mr. Dirk Vuylsteke, a Biotechnologist (Tissue Culture Specialist) – also a Belgian National and Professor Rodomiro Ortiz – a Peruvian Plant Geneticist and Breeder. These world-renowned Scientists were my immediate bosses, mentors who further laid a formidable research capability in me.

The major mandate of IITA's Onne Substation was to multiply and distribute Black Sigatoka (*Myscoshparella fijiensis* Morelet) disease resistant Cooking bananas (*Musa* ABB group) as an interim measure in the short run while synthesizing and genetically breeding Black Sigatoka resistant and high yielding Plantain and Banana (*Musa* sp.) hybrids in the long run in Nigeria in particular and West Africa in general. My position as a Research Associate of the Onne Sub-station opened my eyes for global goal-oriented and time-specific scientific agricultural research. However, the intractability of the genus *Musa* to conventional genetic breeding due to its triploidy (3x=33) genetic constitution made its breeding extremely difficult because of high sterility and consequent low seed-set and often associated with poor seed germination and near zero hybrid production in the field.

This intractability or breeding barrier in the genus *Musa* aroused my curiousity and inquisitiveness. I wanted to investigate this phenomenon and that led me into writing up a Ph.D. Research Proposal in 1992 to Professor Taiji Adachi – a renowned Japanese Plant Breeder and Professor of Applied Genetics & Biotechnology, Miyazaki University, Miyazaki, Japan who graciously provided me with laboratory space and research facilities in his Department and supervised my research work under the Government of Japan (*Monbusho*)

Fellowship programme. Since the genus *Musa* is not grown in Miyazaki, Japan, even under greenhouse culture, we opted for the genus *Manihot* (Cassava) which has a similar polyploidy (triploidy, tetraploidy, pentaploidy, etc) problem and which could be successfully cultivated under greenhouse culture system especially during winter. With due cognizance to my research interests in Genetic Breeding of *Musa*, we agreed that my Ph.D. Research Work and Dissertation be entitled, ***Embryological Analysis of Breeding Barriers, Apomixis and Genetic Improvement in Cassava (Manihot esculenta* Crantz)(Ogburia, 1996).** This research dissertation was successfully concluded and defended in the United Graduate School of Kagoshima University, Japan in 1996. The findings of this work were fundamental in understanding the genetics and breeding intractability of Cassava, Plantains and Banana and other plant genus with similar genetic breeding problems. Part of my discourse this evening will highlight some of the impressive and outstanding results there-off, which if adequately applied by colleagues and other research workers on similar or related plant species would positively impact on humanity. The findings constitute in part, my modest contribution to the wealth of knowledge in Plant Genetics and Breeding in particular and Agricultural Science in general as we shall soon discover in the course of this lecture. Other findings will constitute research outcomes of work conducted here in the Department of Crop/Soil Science of our great University in collaboration with both my under-graduate and post-graduate students with little or no Research facilities and Infrastructure. The lack of adequate Research Infrastructure and Facilities for world-class contributions will be





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highlighted in course of this discourse and I can only wish it meets the attention of our collective consciousness and resolve for timeous improvement.

## 2.0 INTRODUCTION

Mr. Vice Chancellor, Sir! For the benefit of our August audience, permit me to once again, remind them that I am a Professor of the Faculty of Agriculture. Even though everyone here present has at one time or the other planted seeds, or other propagules or reared animals of different species in their farms, gardens, homesteads, lawns, parks etc., or merchandized in crude or refined (processed/value-added) forms of any agricultural produce in either subsistence or commercial scale for man's utility, it would be absolutely necessary to state that they had all engaged in the art and science of Agriculture. This is very correct considering that each and every person plays a role in the agricultural value chain. Consequently, therefore, everybody is a potential Agriculturist, no matter how rudimentary it may seem. Suffice it to also say that humanity lives and dies in Agriculture.

As a Plant Geneticist and Breeder, the title of my lecture is, ***Plant Breeding Science: Ancient and Modern.*** Mr. Vice Chancellor, permit me to dwell on some of the crucial research work accomplished in Plant Genetics and Breeding, integrating other closely related sciences like Agronomy, Biotechnology, Botany, Crop Science, Cytogenetics, Ecology, Histology, Plant Physiology as multidisciplinary strategy for quantum food production for the benefit of humanity and symbolize my humble and modest contribution to societal growth and development. Mr. Vice Chancellor, kindly permit me also to demystify the discipline of Plant Genetics and Breeding which is highly quantitative in nature, by watering down this lecture terminologically because of the

seemingly diverse scientific backgrounds of our august audience. No deliberate attempt will be made to bore you with copious textbook materials (literature review) or complicated formulae, equations, long Tables and Figures usually associated with the discipline. In doing so, deliberate efforts will be made to first and foremost define and explain some of the frequently used terminologies, acronyms and symbols for easy comprehension of the lecture. Pictorial and or micrographic data as easily discernible evidence of my research contributions would rather take centre-stage to make the discourse, rather interactive, stimulatory, comprehensible and memorable.

## 2. 1 Definitions

***2.1.1 Agriculture -*** This is a conscious planting, harvesting and processing of crop plants and the rearing of animals for man's use. It may also include such other services as Agricultural Insurance, Cooperatives and Extension Services etc.

***2.1.2 Plant Genetics and Breeding -*** This is a branch of Agriculture that is primarily concerned with manipulation of plant hereditary characters to develop or synthesize superior phenotypes for humanity. These characters are conferred by genes and these genes are located on chromosomes (Fig. 2). Chromosomes are located largely in the nucleus of every single cell (Fig. 1) of the plant body (somatic cell) and reproductive organs (gametic cell). They may also be found in such plant cell organelles like Chloroplasts and Mitochondria.

***2.1.3 Plant Cell -*** The smallest unit of life of any plant containing organelles such as Nucleus, Nucleuolus, Cholorplast, Mitochondria, Golgi Apparatus, Smooth and Rough Endoplasmic Reticulum, Vacuole, Plasmodesmata,





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All my former and current post-graduate students like, Prof. S N. Wekhe, Prof. P. Anyaegbu, Prof. Ibhaze, Drs. K. Okele, S. Akele, J. A. Orluchukwu, H. Okolie, E. C. Davids, G. C. Amadi, S. Attah, P. Udu, di Umba (Late), C. Akachukwu, G. S. Effiong, A. E. Hart, N. D. Cameroun, V. Adeorike (Mrs.) and S. Yorka who cross-fertilized research ideas with me are gratefully acknowledged. The stimulating interactive lectures with my past and present undergraduate students are also gratefully acknowledged.

I thank my late parents, Mr. and Mrs. Ezekiel Obuange Ogburia for inculcating in me the discipline, self-reliance, courage and dedication needed to accomplish my educational pursuits. May their gentle souls, rest in the bossom of the Almighty God. The sacrifice of my immediate younger maternal sister Mrs. Nneka Oyibo Ifechukwude who was requested to further postponed her own secondary education to pave way for mine, cannot be forgotten. Thank you, my beloved sister and thank God that you are now a graduate too. Remain blessed!

Special appreciation goes to my dear wife, Mrs. Enobong Mike-Ogburia who was also my perfect breeding partner and the loving maternal parent of my beautiful progenies in the perfect genetic ratio of 4:2 (males:females). The Christainly demeanor and peaceful disposition of our progenies contributed in no small measure to the actualization of what is being witnessed today. They are: Moore Ikechi Mike-Ogburia, Emma Mike-Ogburia, Chisa Mike-Ogburia, Minichim Mike-Ogburia (Junior), Naomi Mike-Ogburia and Celestine Mike-Ogburia. God bless you all.

**Thank you all for listening.**





Plasma membrane, Ribosomes, Peroxisome and Nuclear envelope and enclosed in relatively rigid cell wall is called the plant cell (Fig. 1).

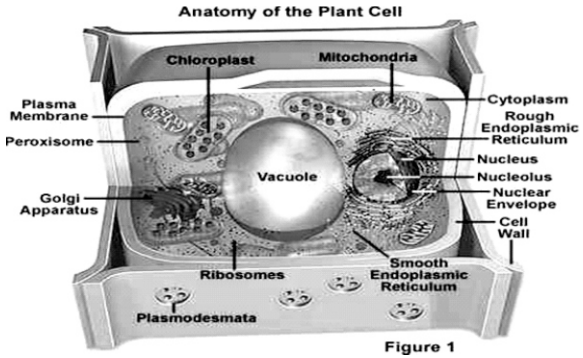


*Fig. 1. The Anatomy of a Plant Cell showing Organelles (Nucleus, Chloroplasts and Mitochonria - chromosome containing organelles are clearly visible. Below is the structure of one chromosome.*

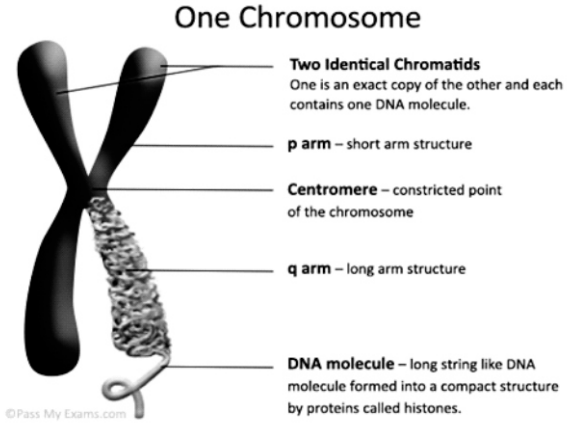


*Fig. 2. The structure of a Chromosome.*

***2.1.4 Plant -*** A plant is defined as a eukaryotic multicellular organism. The Plant Kingdom has about 260, 000 species divided into two phyla (or divisions in plants): Bryophyta (non-vascular plants, lower plants) and Tracheophyta (vascular plants, higher plants). They range in size and complexity from small, nonvascular mosses to giant Sequoia trees, the largest living organisms, growing as tall as 330 feet (100 meters). Only a tiny percentage of those species are directly used by people for food, shelter, fiber, and medicine. Nonetheless, plants are the basis for the Earth's ecosystem and food web, and without them complex animal life forms (such as humans) could never have evolved. Indeed, all living organisms are dependent either directly or indirectly on the energy produced by photosynthesis, and the byproduct of this process, oxygen, is essential to animals. Plants also reduce the amount of carbon dioxide present in the atmosphere, hinder soil erosion, and influence water levels and quality. Virtually all these multicellular organisms called plants directly or indirectly provide food, shelter, medicines, clothing, employment, commerce, furniture, oxygen and many other consumables for humanity.

***2.1.5 Genetics -*** Genetics is derived from Greek and Latin word, *Genesis* and means origin (beginning) or creation (Okoli, 2003). It is the science of origin of biological variations, organization in organisms (eg. Plants) and how these variations are passed on from parents to progenies. Experts in this field are called, ***Plant Geneticists.***





I express my deep sense of gratitude to Dr. K. Kawano – Plant Breeder, Centro Internacional Agricultura Tropical (CIAT), Cali, Colombia Cassava Asian Regional Programme for plant material support., Dr. A. M. Thro – formally, Coordinator, Cassava Biotechnology Network (CBN), (CIAT), Cali, Colombia, now Senior Advisor, Plant Health and Production, and Plant Products, USDA National Institute for Food and Agriculture (NIFA), Washington, USA for Research grant awarded to Prof. N. M. Nassar (University of Brasilia, Brazil) and myself for collaboration on Cassava Cytogenetics Techniques., Dr. M. C. M. Porto – formally a CIAT/IITA Scientist but now of EMPRAPA, Brazil., Dr. R. Asiedu – Leader, Tuber and Root Improvement Programme (TRIP) and Dr. M. Quin – Director, Crop Improvement Division (CID), IITA, Ibadan, Nigeria for their moral and plant material support at various stages of my Doctorate research efforts while in Japan.

I sincerely appreciate Dr. A. Koltunow, Senior Scientist, Division of Horticulture, Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia and Dr. R. Jefferson, Executive Director, Centre for the Application of Molecular Biology in Agriculture (CAMBIA), Australia for scientifically stimulating discussions and suggestions on Apomixis Research in Miyazaki University, Japan and for offering laboratory space for post-doctoral research respectively.

The Graduate Research Fellowship Award of the Government of Japan (***Monbusho***) extended to me is gratefully acknowledged.

I would remain very grateful to the Management of Shell Petroleum Development Company (SPDC), Port-Harcourt for granting me Sabbatical position as Senior Research Advisor, Corporate Health, Security & Environment (HSE) Department.

I am eternally grateful to Professors H. N. Atabaeva and R. U. Hassanshin of the Departments of Crop Science and Tropical Agriculture respectively, Tashkent Agricultural Institute of the former USSR, now Tashkent Agricultural University, Tashkent city, Uzbekistan, for guidance and supervision of my Masters Degree Thesis.

I am deeply indebted to Professor Rony Swennen – a Belgian Geneticist and Breeder and late Dr. Dirk Vuylsteke, a Tissue Culture Specialist – also a Belgian National and Professor Rodomiro Ortiz – a Peruvian Geneticist and Breeder. These world-renowned Scientists were my immediate bosses, mentors who laid a formidable research capability in me.

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***2.1.6*** ***Breeding –*** The application of genetic laws and principles in targeted manipulation of organisms (in this case, plants) in a given environment for man's use. Resultant manipulations are permanent and heritable in nature. Scientists who perform this special work are termed ***Plant Breeders***. The task of manipulating and adjusting natural plant crops to meet humanity's ever increasing demand for improved life can as well be termed ***Plant Improvement.*** Basically, therefore, there is no marked difference between Applied Genetics, Plant Breeding and Plant Improvement as they can be used interchangeably.

***2.1.7*** ♀ - This symbol signifies mirror and associated with the female (maternal) parent in hybridization (genetic manipulation) process. The Women folk hardly do without the mirrow to check themselves up after make-ups and carry it in their handbags or purses wherever they go!

***2.1.8*** ♂ - This symbol or sign depicts a bow and arrow and signifies the male (paternal) parent in any hybridization (genetic improvement) program. The males are natural hunters with bow and arrows for wild animals for food right from time immemorial and even up till this day in some localities. Modern men are also known to be hunters of contracts, power, money and of course women, though not with bow and arrow but with whatever they have in their *arsenal or comparative advantage*!

***2.1.9*** **x** – This sign means a cross or mating between the female and male parent in any breeding program.

***2.1.10*** $F_1$ - This means the First filial generation (population) resulting from any first cross between the female and male parents in any hybridization program and it could be from $F_1$-$F_n$.

# 3 .0 ORIGIN AND HISTORICAL PERSPECTIVES OF AGRICULTURE AND PLANT BREEDING

## 3.1 Biblical Account

Mr. Vice Chancellor, Sir! I think it would be worthwhile to briefly intimate our August audience about the history of Agriculture in general and Plant Breeding in particular. Agricultural history is as old as the history of Humanity itself. However, the Holy Biblical account of the history of Agriculture is as presented in the book of Genesis 1:9-12. It reads, *"Then God said, Let the waters beneath the sky flow together into one place, so dry ground may appear. And that is what happened. God called the dry ground land and the waters seas. And God saw that it was good. Then God said, Let the land sprout with vegetation – every sort of seed bearing plant and trees that grow seed bearing fruit. These seeds will then produce the kinds of plants and trees from which they came. And that is what happened. The land produced vegetation – all sorts of seed-bearing plants and trees with seed-bearing fruit. Their seeds produced plants and trees of the same kind. And God saw that it was good"*. From this account, Ladies and Gentlemen, you would not only agree with me that God was the ultimate Agriculturist who created Agriculture itself but also the Superior Plant Breeder! Praise God!

***3.1 Mortal Account*** (*Culled from IFAS Extension, University of Florida, USA and* http://en.wikipedia.org – *accessed 27/04/2017*)

Early humans graduated from hunter-gatherers to Agricultural communities and societies and symbolized the first giant leap to modern civilization. The brief historical





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Most importantly, I thank God Almighty for giving me sufficient grace to contribute to the existing wealth of knowledge in Agricultural Science in general and Plant Genetics and Breeding in particular and for sharing such information today with you all. I also thank all the teachers who taught me in my formative years. I can never reward you all, adequately! May God reward and bless you all.

I am indeed very grateful to our dear Executive Governor and Visitor Barr. Ezebunwo N. Wike (CON) for the amicable settlement of the RSUST ASUU-RVSG impasse mentioned earlier and his subsequent recall of all striking lecturers including me.

I am forever thankful to our amiable and dynamic Vice Chancellor, Professor B. C. Didia for giving me the opportunity to present my academically fulfilling Inaugural lecture today. I also want to put it on record that this is not the first time Mr. Vice Chancellor has given me an opportunity to accomplish something tangibly remarkable. He gave me a second opportunity to life, having single-handedly, courageously and diplomatically negotiated and secured my unconditional release from the cruel hands of kidnappers in January, 2016. Thank you so much, Sir! God bless you!

I am profoundly grateful to my childhood friend, through whom God used in opening my Tertiary Education doors, without whom I probably would not have travelled abroad in the first place, to acquire a University Education, Mr Charlse Okpara, Thank you, my brother.

5. Strong collaborations and linkages among scientists of diverse disciplines and consumers should be facilitated in Plant Breeding Programmes to develop crop ideotypes that would possess all the desirable attributes for humanity.

6. Finally, Plant Breeding Scientists must incorporate, internalize and practice the ancient and modern technologies of Plant Breeding as a ***creed*** for the benefit of humanity just as we sing ***Hymn: Ancient and Modern*** during worships in our holy churches in praise of God Almighty, our Creator for alleviation of our numerous earthly problems and for eternal salvation and place in heaven.





landmarks in Plant breeding science as recorded by mortal scientific man is as presented in Table 1.

*Table 1: A brief historical Milestone in Plant Breeding Development in the World from Ancient to Modern Times*

| Time Frame | Developmental Activity and Achievements by some notable Plant Breeders |
|---|---|
| **8000 BC** *(Early history of Plant Breeding)* | About 10,000 years ago, in an area known as the Fertile Crescent, mankind began its long history of Agriculture. The Ice Age was ending and human populations were increasing. Until this time, people ate by hunting and gathering their food. Farming likely began in areas filled with animal dung, because people noted that seeds planted in these areas grew better, however these early crops bore little resemblance to those we see today. Early Plant Breeders (probably women) domesticated wild plants by artificially selecting the best plants, harvesting the seeds and replanting them. A domesticated plant is one that has been artificially selected by humans. Artificial selection was practiced when humans collected seeds from stronger plants and replanted them. Wheat was one of the earliest crops to be domesticated, followed by barley, flax (a fiber), peas and lentils. Humanity changed from then as that singular act of artificial plant selection launched us on the path of technological society we find ourselves today. |

| *Time Frame* | *Developmental Activity and Achievements by some notable Plant Breeders* |
|---|---|
| **1700's (Industrial Revolution)** | Farming changed very little until the early 1700s when an agricultural revolution took place. In England, the seed drill was invented reducing the amount seed wasted when planting allowing farmers to sow seeds in straight rows and at specific depths. Crop rotation restored depleted soil nutrients and reduced insects and pathogen buildup in same field by growing different crop types in sequential seasons. Soil structure and fertility are balanced by planting heavy feeding crops like Maize and following the next year with Cowpea or a green manure crop. A green manure crop is one grown specifically to be ploughed back into the soil thereby increasing soil quality and nutrients. These new farming techniques increased crop yields which in turn created a small population boom. In this manner farming paved the way creating the additional manpower needed to stoke the wheels of the Industrial Revolution. |
| **Mid 1800s (Mendel's Pea Experiments)** | A young Austrian Monk and Priest named Gregor Mendel began to experiment with breeding Peas plants in the courtyard of the small abbey in which he taught. He correctly noted that traits in Pea plants were inherited. This was a new idea at the time; previously it was thought that the environment (soil, water, sunlight and weather) influenced traits. As an amateur scientist, Mendel's simple breeding experiments with peas gave birth to the idea of Heredity. **Heredity** is the biological process whereby genetic factors are transmitted from one generation to the next. Mendel's discovery was largely ignored then lost, not to be rediscovered for almost 50years.- |





genebanks or in the laboratories as cryopreservation (via liquid nitrogen) or *in-vitro*. Destruction of seemingly unattractive or non-tangible yield productive genotypes in the field by ***unintelligent*** or ***intellectually blind*** individuals should be discouraged, if not for their free oxygen ($O_2$) release at least, but because their futuristic potentials cannot be under-estimated. The cure for some dreaded diseases like Autism, HIV/AIDS etc. could be found in such germplasms. Until recently, little did we know that roots of plantains could be effective in the treatment of Prostratitis, Diabetes and Kidney diseases.

2. Application of modern or novel molecular and biotechnology tools in food crop improvement methodologies should be encouraged through the provision of appropriate facilities and human capital development by government, public-spirited corporations and individuals for quantum food production in Nigeria. Ancient or classical breeding approaches should continually be relevant, improved and integrated in modern breeding technologies for sustainable and reliable food crop production.

3. Unrestricted cultivation and consumption of transgenic plants or Genetically Modified Organisms (GMOs) should be advocated in Nigeria after rigorous bio-safety checks have been concluded on them, for sustainable food self-reliance and to boost our National economy.

4. Adoption of crop hybrids or varieties in our traditional farming systems should be encouraged among our farmers because of their superior agronomic performance over landraces for economic profitability. This can be achieved through *on-farm* demonstrations on farmers' farms as ***seeing is believing***.

hybrids of crop plants are sustained to identify useful genetic traits for introgression.

National and International Research Collaborators are welcome! From the economic standpoint, the cultivation of hybrid varieties has shown to be profitable, well over their landrace counterparts, which in turn improves farmers' well-being and therefore, sustained adoption of hybrid varieties in our farming system and therefore is advocated for poverty eradication, hunger reduction and disease eradication in our land as we look forward to the dividends of the ***State of Emergency on Science and Technology*** recently declared by the Federal Republic of Nigeria.

Mr. Vice Chancellor, sir, I would conclude this lecture by citing the remarks of Nobel Laureate Norman E. Borlaug who said: ***"For those of us on the food production front, let us remember that world peace will not – and cannot – be built on empty stomachs. Deny farmers access to modern factors of production – such as improved varieties, fertilizers and crop protection chemicals – and the world would be doomed not from poisoning, as some say, but from starvation and social chaos."***

## 9.0 RECOMMENDATIONS

Mr. Vice Chancellor, sir, it would only be imperative at this juncture to proffer some recommendations which are anchored on my personal research experience in genetically improving crop plants for humanity.

1. Conservation of existing genetic biodiversity of major food crops like Plantains/Bananas, Cassava, Rice, Maize, Soybeans, Fluted pumpkin, Groundnuts etc. and creation of new ones through hybridization should be sustained for food crop improvement programmes if humanity must be sustainably preserved. This can be achieved as field





| *Time Frame* | *Developmental Activity and Achievements by some notable Plant Breeders* |
|---|---|
| **1864- 1943 (George Washington Carver)** | George Washington Carver overcame illness and slavery to become one of the most respected scientists of his time. Carver's new concept was Crop Rotation where cotton crops were alternated with peanuts and field peas. Peanuts and Peas are legumues, a type of plant that actually manufactures a crucial crop nutrient, nitrogen from the air. By rotating heavy feeding crops like cotton with peanuts, farmers not only had a second crop to sell or feed livestock, but legumes add soil nutrients, making the soil more productive. So successful was this technology that Carver was forced to find alternate uses for the huge amounts of peanuts, sweet potatoes and other crops realized in this soil-replenishing crop rotation. Carver discovered over 400 different products and uses from peanuts and sweet potatoes alone, including peanut butter! Carver felt that his discoveries were best shared by all men and patented only three of his discoveries. |
| **1940 - 1970's (Wheat for the World)** | In 1940s Dr. N. E. Borlaug began to breed a high yielding, disease resistant wheat to address Mexico's grain shortage. The country needed to import expensive wheat from other countries to feed its people. Borlaug's dwarf wheat plants yielded two to three times more than earlier varieties. Mexico soon had enough wheat to feed the nation with a surplus to export to other countries. Borlaug took his plant breeding skills to assist other developing countries, including India and Pakistan. Mexico took almost 15 years to become self-sufficient in feeding its nation; India only took 3years. One wheat breeder saved |

| *Time Frame* | *Developmental Activity and Achievements by some notable Plant Breeders* |
|---|---|
| | millions of people from dying of starvation. Dr. Borlaug received the Nobel Prize for Peace in 1970 for his achievement. |
| **Early 1900s (Hybrid Maize)** | In 1906 - 1908, George Harrison Shull began experiments on inheritance in Maize. He discovered that if he crossed two corn plants that were different, it resulted in more stable corn varieties. These two stable breeding lines were then crossed resulting in hybrid corn. Mixing the genetics of dissimilar corn types creates a hybrid or blending of the parents' characteristics, but in a predictable way. By mixing the parents' genes, Schull's hybrids were stronger than their parents and higher yielding. Hybrid breeding technology was soon adopted by breeders of other crops. Coupled with advances in chemical fertilizer and pesticide, hybridization helped to boost crop yields to historic levels through the 1900s. By 1920s, statistical methods were developed to analyze gene action and distinguished heritable variation caused by environment. In 1933 another important breeding technique, Cytoplasmic Male Sterility (CMS), developed in Maize was described by Marcus Morton Rhoades. CMS is a maternally inherited trait that makes plant produce sterile pollen grains. This enables the production of hybrids without the need for labour-intensive detasseling. Today over ninety (90%) percent of vegetable crops are grown as hybrids in the world. |





## 8.0 CONCLUSIONS AND OUTLOOK

Mr. Vice Chancellor, sir, I have attempted to present in a chronological manner, the origin and historical insights of ancient and modern Agricultural development in general and Plant breeding in particular for the benefit of humanity. Plant genetic and breeding impediments inherent in the reproductive biology of some crop plants, especially in cassava have been elucidated. Asexual (vegetative) propagation of cassava (via stem cuttings) and plantains/bananas (via suckers) and their polyploidy status could have impacted their sexual reproductive genes thus leading to sexual reproductive blind alley.

A modern cytogenetic technology for advancement of cassava plant genetic and breeding research has been developed and accepted world-wide. Efforts have been made to advance the frontiers of genetically improving recalcitrant crops like cassava and plantains for all. At present, maximum yield and durable host disease resistance is our priority but we are not overlooking other attributes such as nutritive quality, nutrient-use efficiency and adaptation to climate change in our breeding programme. The need to incorporate ideas and preferences of the ultimate consumers of food crops in the breeding process has been advanced. The application of modern molecular genetics and biotechnology in complementing classical breeding methods has shown greater promise in plant improvement processes.

All these would not happen if there are no plant biodiversity and well-equipped laboratory! Our ever expanding field genetic conservation and germplasm bank in our University Teaching and Research Farm is an invaluable resource that comes handy for continuous genetic and breeding research. Agronomic evaluation of wild plants, landraces and somaclonal variants as well as derivative

This implies that there was a deficit of ₦40, 750 in the business. It is evident that if a farmer makes use of any cultivar that gives less than or about the same grain yield like the average grain yield obtained in this research (1.52t.ha$^{-1}$), that farmer will incur serious economic losses. By using the average yield obtained from best two rice cultivars which have been selected (*WITA 4* and *BW 348-1* (2.0t.ha$^{-1}$), sales worth ₦1, 700,000 became higher than cost of production (₦1, 332, 750). This yielded a profit margin of ₦367, 250 for the two cropping years according to Ogburia *et al*., (2006). Similarly, Ogburia and Okele (2003) have shown the profitability of cultivating hybrid cassava in a humid agro-ecological zone of Nigeria.

*Table 33: Putative farm accounting using selected two best rice cultivars*

| Expenses | | Sales |
|---|---|---|
| Rice paddy used for 2002/2003 (510kg @ 1kg/ 25) | 12,750.00 | Average grain yield of 2 b WITA4/BW348-1=2t/ha) are used |
| | | * 2002 (7ha x 1.52tons @ 2,500/50kg) |
| | | * 2002 (10ha x 1.52tons @ 2,500/50kg) |
| **Cost of Labour** | | |
| (Total man-days utilized to cultivate 1ha = 300md @ 200 250/md) | | |
| * 2002 ÷ 300md x 200 x 7ha | 420,00.00 | |
| * 2003 ÷ 300md x 200 x 10ha | 750,000.00 | |
| Cost of Agrochemical | 150,00.000 | |
| **Total** | **1,332,750.00** | **Total** |
| Net income = sales - expenses | 1,700,000.00 - 1,332,750.00 = 367,250.00 | |





| *Time Frame* | *Developmental Activity and Achievements by some notable Plant Breeders* |
|---|---|
| **1950's (Jumping Genes)** | Dr. Barbara McClintock (1902-1992) was one of the most prominent female Scientist of the twentieth century. Her discovery in 1952 was so radical that her fellow scientists did not accept it until 20 years later. McClintock studied mutation in the kernels of corn and was the first scientist to report ***jumping genes*** but the technology did not exist at that time to prove it. At the time, it was believed that genes remained on a specific portion of the chromosome. She noticed in Indian corn that some of these genes (carrying traits) were transposable. Transposable genes could move not only on one gene but ***jump*** from gene to another. She won the Nobel Peace Prize in Medicine in 1983. Her work was a driving force showing the increasing role genetics played in plant breeding. Her research paved the way for the biotechnical plant breeding and the genetically modified crop boom just ahead. |
| **1970's - Today (Genetically Modified Organisms) (GMOs)** | The 1970s saw the first breakthroughs in recombinant DNA technology now known in Plant Breeding as transgenic breeding or breeding genetically modified (GM) crops. By taking a section of DNA from organism and inserting it into a crop plant's DNA, geneticists were able to begin the next big step in plant breeding history. Compared to conventional breeding, transgenically bred crops contain traits not found in the species. The transgenic breeder has more control over what characteristics can bred into a plant. Today plant breeders strive to create crop varieties that need |

| Time Frame | Developmental Activity and Achievements by some notable Plant Breeders |
|---|---|
| | less water, fertilizer and chemical pesticides. By the early 1990s the first commercial GM crops were planted. Today 85% or more of cotton, corn and soybean crops grown in the US are genetically modified. |

According to Borlaug, (1983), archeological evidence indicates that more than 3000 species of plants have been used by man for food. Currently, the world's people largely depend on about 29 crop species for most of their calories and protein. These include 8 species of cereals, which collectively supply 52% of the total world food calories, 3 root crops, 2 sugar crops, 7 grain legumes, 7 oil seeds ant 2 so called tree food crops (bananas/plantains and coconuts). These 29 basic food crops are supplemented by about 15 major species of vegetables and a like number of fruit crop species which supply much of the vitamins and some of the minerals necessary to human the diet. These 29 basic food crops were not created by any known man or scientist but evolved as landraces through natural inter-specific hybridization and selection but were merely domesticated by the early men or most probably early women. Modern man, however, had always tried to genetically improve the quantum of their yields through applied genetics or breeding for humanity.

Mr. Vice Chancellor, Sir! May I at this juncture inform you that my plant genetic improvement research efforts were with higher crop plants such as Soybean (*Glycine Max.* Merrill), Groundnut (*Archis hypogae* L.), Rice (*Oryza sativum* L.), Maize (*Zea mays*), Fluted pumkin (*Telfairia occidetalis*





This finding confirms those of De Datta (1981) and NCRI (1997), who discovered that rice grain yield during wet season, is generally higher than in dry season probably due to dry season's environmental stresses exerted on the rice plant. The average grain yield obtained throughout the experiments (2002-2003), for all cultivars was 1.52t.ha$^{-1}$. Using the average grain yield (1.5t.ha$^{-1}$) for computation, cost of production (₦1, 332, 750) was higher than the total sales or receipt (₦1, 292,000), Table 33.

*Table 32: Actual farm account records*

| Expenses | □ | Sales |
|---|---|---|
| Rice paddy used for 2002/2003 (510kg @ 1kg/ 25) | 12,750.00 | Average grain yield of all the ten years is approximately 1.52 t/ha |
| | | * 2002 (7ha x 1.52tons @ 2,500/50 |
| | | * 2002 (10ha x 1.52tons @ 2,500/50 |
| **Cost of Labour** (Total man-days utilized to cultivate 1ha = 300md @ 200 250/md) | | |
| * 2002 ÷ 300md x 200 x 7ha | 420,00.00 | |
| * 2003 ÷ 300md x 200 x 10ha | 750,000.00 | |
| Cost of Agrochemical | 150,00.000 | |
| **Total** | **1,332,750.00 Total** | |

Deficit = sales - expenses

1,332,750.00 = 40,750.00 1,292,000.00

* - Nigerian Currency (Naira) = 127.00 -$1.00

(Ogburia *et al.,* 2006).

Grain yield differed among the 10 rice genotypes and between the cropping seasons ($P \leqslant 0.05$). Among the rice genotypes, *WITA 4* and *BW 348-1* had the highest grain yield of 2.19t.h$^{-1}$ and 2.14t.ha$^{-1}$ respectively, while *TOX 4304-13-1-1-2* gave the lowest grain yield of 1.03t.ha$^{-1}$. Between the two cropping season, wet season gave higher grain yield (1.66t.ha$^{-1}$) than the dry season (1.38t.ha$^{-1}$). This was partly attributed to dry season environmental factors, especially higher soil salinity level which negatively correlated ($r$ = -0.63) with rice grain yield (Table 32).

*Table 31: Ranking of Salinity tolerant levels of 10 swamp rice cultivars, using grain yield (t/ha)*

| Rice Cultivar | Average soil salinity value (2002/2003) (us/cm) | Average grain yield (t/ha) |
|---|---|---|
| *WITA 4* | 4740 | 2.19 |
| *BW 348 – 1* | " | 2.13 |
| *CISADANE* | " | 1.80 |
| *CK 73* | " | 1.79 |
| *ROK 5* | " | 1.41 |
| *WAR 77 - 3 - 2 – 2* | " | 1.34 |
| *FARO 50* | " | 1.29 |
| *WAR 1* | " | 1.17 |
| *DA 29* | " | 1.04 |
| *TOX 4303 - 13 -3 -1 -2* | " | 1.03 |

**Correlation is significant at 0.01 level of significance at the0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)
Dry season soil salinity regime (2002) = 6460 µs/cm; Dry season soil salinity, regime (2003) = 5600 µs/cm
Wet season soil salinity regime (2002) = 3400 µs/cm; Wet season soil salinity regime (2003) = 3500 µs/cm (Ogburia *et al.,* 2006).





HOOK F.), Cassava (*Manihot esculenta* Crantz), Plantains and Bananas (*Musa* sp.) utilizing both the ancient and modern breeding approaches. This discourse will anchor on the fundamentals of Applied Plant Genetics in relation to Agronomy for Societal well-being as simply expressed below.

♀ + ♂ = $F_{1-n}$ = P = G x E where ♀ is the maternal parental source, ♂ is the paternal parental source, $F_{1-n}$ is Filial generations one to infinity and while P is the phenotype or the physically quantitative measurable appearance of progenies, G is the Genotype and E, the Environment (Soil Type, Mineral Nutrition including organic and inorganic Fertilizers which can be in either solid or liquid state, Solar Irradiation, Rainfail, Humidity, Temperature etc.). The interactions of the expression will be explained and referred to in due course as the lecture progresses.

## 4.0 PLANT GENETICS AND BREEDING

Gregor Mendel (1822-1884) is considered the *Father of Genetics* even though genetic analysis predates him but his laws form the basis of our modern understanding of the genetics of inheritance. Mendel made three innovations to the Science of Plant Genetics and Breeding with his experiments with peas in which he developed pure lines, counted his results and kept statistical records. *Mendelian Genetics or Mendelism* as is popularly known is famous with three outstanding laws viz: 1. Law of Dominance 2. Law of Segregation and 3. Law of Independent Assortment. These laws are fundamental in the practice of Applied Plant Genetics or Plant Breeding of all Plants of value to humanity.

## 4.1 Plant Cytogenetics for Plant Breeding Advancement

Mr. Vice Chancellor, Sir! The intractability of the genus *Musa* to conventional genetic breeding due to its triploidy (3x=33) genetic constitution which made its breeding extremely difficult because of high sterility and consequent low seed-set with associated poor seed germination and near zero hybrid production in the field was a huge challenge. Consequently, cytogenetic and embryological methodologies became indispensable in sub-cellular understanding and surmounting the genetic improvement and breeding barriers of these economically important crop plants and others of similar polyploid status.

The conventional ancient paraffin or more recently resin embedded-sections have long been used in the study of ovule and megagametophyte ontogeny in angiosperms. Even though they generally yield high contrast preparations with excellent clarity, they have some major constraints (Jongedijk, 1987). Firstly, the production of microscopic slides is laborious and time-consuming. Secondly, the quantitative interpretation of the investigated phenomena is tedious because three dimensional structures are often distributed over several serial sections and thus require reconstruction of the full image. Paucity of cytological information on agamospermy exemplifies the need for suitable cytological techniques (Stelly *et al*., 1984). Since Herr's (1971) introduction of the benzoate-four-and-a-half clearing techniques for the study of ovule development in angiosperms, some modification of the original method have been made to suit specific objectives (Farence and Smith, 1975., Shealy, 1980).





material for the manufacture of beer, spirit and wine in brewing industries; making of bread, cakes and biscuits and other food products in the food/livestock feed industries (Ebong, 1993). It is also important to note that rice is not only a key source of food, but a major employer of labour and source of income for the poor (WARDA, 2004). Nigeria has over 4 million hectares potential area for both swamp and upland rice production. But the actual area under cultivation is approximately one million, which is about 22% of the potential area (NCRI, 1997; Akande, 2003). About 0.42 million hectares of wet land is currently put under lowland rice production while approximately 0.58 million hectares of upland area is put under upland rice cultivation. The wetlands comprise saline mangrove and freshwater swamps, shallow and deep water fadamas and irrigated plots (NCRI, 1997; Akande, 2003). Due to the peculiar saline soil condition of the agro-ecology, the need to introduce, screen and select salinity tolerant swamp rice cultivar was conceived.

This investigation was conducted in wet and dry seasons to analyze the level economic returns from cultivating hybrid swamp rice cultivars in a tidal saline mangrove agro-ecological zone in the meander belt of Niger Delta Region of Bayelsa State of Nigeria. In determining the economic efficiency of 10 rice hybrids cultivation, financial returns were considered by recording monetary value to the yield and cost of production. Consequently, profit from hybrid rice cultivation was taken as yield sales minus production cost as modified by Brockman (1988) and used for economic analysis of hybrid cassava cultivation by Ogburia and Okele (2003)

*Table 30: Performance of some morphological traits of Musa AAB somaclones*

| Genotype | No. of young leaf spotted (YLS) | Plant height (cm) | Total no. of leaves |
|---|---|---|---|
| *7152 – 2 (PITA 14)* | 4.35a | 244.57bc | 30.71b |
| *5511 – 2 (PITA 3)* | 3.88b | 257.54a | 31.73ab |
| *AO2B1 - 2* | 3.84b | 245.16bc | 32. 7a |
| *AOB2 – 1* | 3.84b | 249.76bc | 30.67b |
| *B.Egome* | 3.71bc | 243.33c | 31.31ab |
| *AO1B1 – 2* | 3.69bc | 251.53ab | 31.88ab |
| *AO2A2 – 2* | 3.63c | 202.11c | 2.41ab |
| *BO4A2 – 2* | 3.62c | 233.78d | 32.12ab |
| *BO4A1 – 2* | 3.55c | 235.51d | 30.33ab |
| *Agbagba* | 3.23d | 202.01c | 31.98ab |

Means with the same letter are not significantly different at $P \leq 0.05$ (Udu *et al.,* 2002).

## 7.4 Profitability of Hybrid Plant Cultivation

Mr. Vice Chancellor, sir! Rice (*Oryza* sp.) is valued as the most important staple food for over half of the world's population (AgriNews, 2003). It ranks third after wheat maize in production on world basis (Imolehin, 1999). More than half of the world's population depends on rice as the major source of calories (FAO), 2003). The amount consumed by each of these people ranged from 100kg to 240 kg per annum (FAO, 2003). Rice could be cooked, boiled, steamed and eaten with soup (pepper soup inclusive) stew, beans, meat, fish, and vegetables. It is also an important raw



In Farm animal and human cytogenetics, Berepubo *et al*., 1997 and Wekhe *et al.,* (1998, 2002, 2006) assayed veinous serum for *X*-chromatin pattern, drumstick and blood relationship with modern cytogenetic techniques using Leishman's stain technology. Alternative rapid cytogenetical, cytoembryological and cytohistological techniques for megasporogenesis and or ovule ontogeny were urgently needed for obtaining cytogenetic information of Cassava (*Manihot esculenta* Crantz) for its genetic improvement. Three pre-existing stain-clearing techniques (benzyl benzoate-four-and-a-half (BB-$4^1/_2$ fluid, Mayer's hemalum and 100% methyl salicylate) and a simple modification involving a conjugation of BB-$4^1/_2$ fluid and methyl salicylate in a ratio of 1:1v/v was applied in the cytogenetic study of ovule ontogeny in cassava to establish their efficacy as a rapid cytohistological technique. Asian Cassava pistils of varying developmental stages were sampled and fixed in Farmer's fixative (95% ethanol:glacial acetic acid = 3:1). Dissected ovules were cleared with the methods mentioned earlier and observed with Nomarski's Differential Interference Contrast (DIC) microscopy. The modified technique yielded better imagery (clarity, precision and contrast) of the morpho-structural features or components of cassava embryo-sac compared to the former methods (Table 2; Fig. 3). Consequently, this modified technique was employed to investigate reproductive and breeding barriers in the genus, *Manihot*.

*Table 2: Summary effects of some cyto-histological techniques on ovules of cassava – Manihot sp.*

| Technique | Optical effect | Reference |
|---|---|---|
| BB – 4 ½ Fluids + Methyl Salicylate | Good. Better images of embryo-sac component | (Ogburia, 1994., 1999) |
| BB-4 ½ Fluids | Poor. Obscured view of cytoplasm and nuclei | Herr, (1971) |
| Mayer's hemalum | Poor. Over-staining of embryo-sac structures | Pfeiffer & Bingham (1983)., Stelly *et al.,* (1984) |
| Methyl salicylate | Fairly good. Good images of cytoplasm and nuclei | Crane (1978)., Young *et al.,* (1979) |

Ogburia, 1999

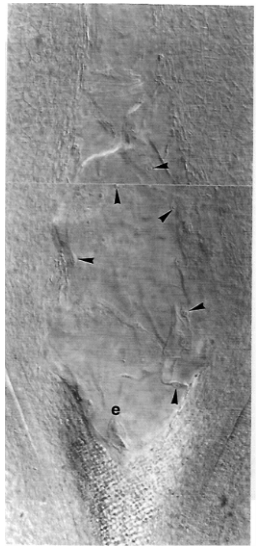


***Fig. 3. A developing fertilized embryo (e) in an embryo sac with free endosperm cells (arrowheads) at 14 days post pollination. Note the torpedo-shaped embryo. Source: Ogburia, 1996.***





*vitro* culture techniques, with conventional multiplication and breeding activities (Swennen and Vuylsteke, 1989). Somaclonal variations have been isolated using in-vitro culture technology and are attributed to genetic mutation during micro-propagation (Scowcrot, 1984). The occurrence of phenotypic variations among in-vitro micro-propagated plants of *Musa* confirms that it is a common phenomenon in the genus. Previous work at IITA led to the selection of somaclones of plantain landraces putatively resistant to black sigatoka disease (Nwauzoma, 1999).

Host response to black sigatoka disease was evaluated using the Vakili (1968) method, which consist of recording the youngest leaf spotted (YLS). A high YLS value indicates more functional leaves on the plant and hence a greater resistance to the fungus. Data on morphological traits were subjected to statistical analysis using statistical analysis system procedures (SAS Institute, 1992).

Enhanced host response to black sigatoka disease pressure was obtained in the hybrids (*PITA 3 and PITA 14*) and *Agbagba somaclones* (Udu *et al.,* 2002). Less resistance in the *Bise Egome somaclones* with and across location revealed pre-existing genotypic variations (Table 30).

(45 l). Maize height was increased by 4.8%, leaf area by 1.4%, leaf area index by 30.40% and yield by over 130% in treatment $L_3$ (45 l) over the control respectively (Table 29).

**Table 29: Effect of foliar application of liquid manure on the productivity of maize**

| Treatment (litres) | Plant height (cm) | Leaf area ($cm^2$) | Leaf area index | Yield ($tha^{-1}$) |
|---|---|---|---|---|
| $L_0$ (0) | 179.95 | 521.28 | 0.70 | 1.64 |
| $L_1$ (15) | 181.70 | 522.45 | 0.82 | 2.67 |
| $L_2$ (30) | 185.75 | 526.70 | 1.80 | 2.98 |
| $L_3$ (45) | 188.55 | 528.55 | 3.11 | 3.7 |
| $L_4$ (60) | 182.80 | 523.60 | 3.00 | 3.26 |
| LSD P< 0.05 | 0.77 | 1.14 | 0.44 | 0.55 |

(Effiong *et al.*,2006).

## 7.3 Black Sigatoka Disease Evaluations in Plantains

Vice Chancellor, Sir, we evaluated Plantain-derived somaclones and hybrids for resistance to black sigatoka disease (*Myscosphaerella fijiensis* Morelet) under different cropping systems in a humid ecology. Crop losses by this disease have given rise to research efforts aimed at improving the genetic materials of *Musa* (Persely and De-Langhe, 1987). Resistance breeding is a preferred option, but fraught with many obstacles specific to the biology of the preferred parthenocarpic *Musa* cultivars. Low clonal multiplication rates, lack of variability, and barriers to sexual hybridizarion such as female sterility reduce the rate of genetic improvement. To overcome these constraints, IITA used *in-*



Abnormal embryo-sacs presented notable irregularities at both pre- and post-anthesis developmental stages, such as varying number of nucleate cells, lack of nucleate cells (9.1%), 12.5% reduction in volume or non-existent (Table 3). There was no correlation between ovule size and embryo-sac volume ($r^2$ = 0.038 = ovule length and $r^2$ = 0.001 = ovule width) up till 7 days after controlled pollination (DACP). Ovule hypertrophy accounted for 3.3%. All abnormal embryo-sac showed independent and normal development of nucellus and both inner and outer integuments, suggesting that morphologically normal but botanically false seeds could be produced (Fig. 3). These abnormalities are implicated as largely responsible for cyto-embryological basis for fertilization failure, seed abortion, and poor seed set and recalcitrant germination in the genus *Manihot* (Fig. 4). Two distinct but complimentary developmental pathways of reproductive and breeding barriers in cassava were elucidated and schematically illustrated in Fig. 3. (Ogburia and Adachi, 1994, Ogburia and Adachi, 1995., Ogburia, 1999b).

*Table 3. Embryological analysis of ovule and embryo-sac development at pre- and post- pollination in cv. Rayong 3.*

| Stage | No. of Ovules observed | Ovule size (mm) | | Embryo sac vol. ($mm^3$) | Max. volume $\geq 0.007mm^3$ | Malformed embryo sacs | Type of Malformation |
|---|---|---|---|---|---|---|---|
| | | Length | Width | | | | |
| Bud | 33 | 2.1±0.26 | 1.2±0.16 | 0.004±0.001 | 0.007±0.000 | 3(9.1) | Non meiotic |
| Anthesis | 30 | 1.7±0.09 | 0.9±0.08 | 0.004±0.001 | 0.008±0.000 | | |
| 6 HACP | 30 | 1.8±0.10 | 1.0±0.6 | 0.006±0.001 | 0.007±0.000 | 1(3.3) | Non mitotic |
| 12 HACP | 30 | 1.8±0.09 | 1.0±0.09 | 0.005±0.001 | 0.008±0.001 | 1(3.3 | Non mitotic |
| 1 DACP | 30 | 1.8±0.08 | 1.0±0.07 | 0.006±0.001 | 0.007±0.000 | | |
| 2 | 30 | 1.8±0.14 | 1.0±0.08 | 0.005±0.002 | 0.008±0.001 | | |
| 3 | 30 | 2.1±0.06 | 1.0±0.07 | 0.006±0.001 | 0.008±0.000 | | |
| 4 | 30 | 1.9±0.17 | 0.0±0.09 | 0.007±0.002 | 0.008±0.002 | | |
| 5 | 30 | 2.2±0.28 | 1.0±0.07 | 0.013±0.009 | 0.015±0.009 | | |
| 6 | 30 | 2.1±0.46 | 1.0±0.14 | 0.015±0.014 | 0.018±0.014 | 3(10.0) | Reduced vol. |
| 7 | 63 | 2.1±0.12 | 1.0±0.05 | 0.008±0.002 | 0.009±0.002 | | |
| OP | 30 | 2.0±0.016 | 1.0±0.04 | 0.007±0.002 | 0.008±0.001 | 1(3.3) | Hypertrophy |

a. Data indicate the mean ± SD; Bud – Pistillate flower at 1 day beforeanthesis;b.HACP–HoursaftercontrolledpollinationDACP-Daysafter controlled pollination; OP – Open pollinated (unknown days after natural pollination)(OgburiaandAdachi,1994).

Mr. Vice Chancellor Sir, the results of this study was first presented and published in the Proceedings of the Second International Scientific Meeting of the Cassava Biotechnology Network (CBN) in Bogor, Indonesia in August, 1994 and it attracted wide attention and publicity among Cassava Geneticists and Breeders to the extent that the University of Brasilia team led by Professor Nagib M. Nassar (an Egytian-born Brazilian Cassava breeder) collaborated with us and this eventually saw me as a Visiting Scientist travelling to Brazil from Japan for the first time under a research grant award by the CBN/CIAT. It is also important to state here that our improved rapid cytogenetic technique has since been acceptable and applied in cassava cytogenetic, genetic and breeding research, world-wide. You will therefore, all agree that our modest Cytogenetic





Mr. Vice Chancellor, sir! The positive impacts of fertilizers (organic and or inorganic) applied as basal or even liquid fertilizers (fertigation) applied through irrigation water or through sprinklers or sprays on crop plants' productivity is not new. Effiong *et al*., 2005 investigated the response of *Telfairia occidental* HOOK F. to different rates of foliar application of liquid manure in acid sands of Akwa Ibom State, Southeastern Nigeria and found significant effect on leaf area, number of pods per plant and seeds per pod (Table 28).

**Table 28: Effect of foliar spray of liquid manure on some growth and yield parameters of *Telfairia***

| Treatment (litre) | Vine length (cm) | No. of Leaves | Leaf area $(cm)_2$ | Leaf area index | No. of pods/plant | Pod girth (cm) | Pod length (cm) | Pod mass (kg) | No. of seeds/pod | Seed size (cm) | Seed mass (kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| L0 (Control) | 121.08 | 12 | 83.28 | 12.17 | 3 | 89.67 | 53.73 | 5.73 | 79 | 4.1 | 2.1 |
| L1 | 106.33 | 10 | 79.18 | 12.30 | 2 | 79.50 | 44.85 | 3.03 | 81 | 3.9 | 2.2 |
| L2 | 123.17 | 10 | 93.25 | 14.27 | 3 | 90.00 | 44.50 | 3.43 | 89 | 4.1 | 2.3 |
| L3 | 132.67 | 13 | 112.82 | 14.42 | 4 | 92.75 | 49.23 | 4.40 | 91 | 4.0 | 2.8 |
| L4 | 106.42 | 12 | 74.37 | 13.30 | 3 | 88.00 | 46.30 | 4.10 | 88 | 3.1 | 2.2 |
| LSD(P = 0.05) | NS | NS | 17.93 | NS | 0.31 | NS | NS | NS | 8.38 | NS | NS |

(Effiong *et al.,* 2005).

Similarly, the response of different rates of foliar application of liquid manure on the productivity of Maize (*Zea mays* L.) in acid sands of Akwa Ibom State was also investigated. Results showed that foliar application of liquid manure had significant ($P \leqslant 0.05$) effects on maize height, leaf area, leaf area index and yield of maize (Effiong *et al*., 2006). Maize height varied from 179.95 to 180.55cm while leaf area varied 521.28 in the control to 528.55$cm^2$ in treatment $L_3$ (45 l). The highest yield of 3.778t $ha^{-1}$ was also obtained in treatment $L_3$

**Table 27: Effect of different N rates on some agronomic parameters of three soybean varieties**

| Variety | N rate | | | | | |
|---|---|---|---|---|---|---|
| | $N_0$ | $N_{50}$ | $N_{100}$ | $N_{150}$ | $N_{200}$ | $N_{250}$ |
| | | | *Height (cm)* | | | |
| *Yuldus* | 68.1f | 72.5c | 82.0c | 91.0a | 88.2b | 80.2d |
| *Dustlik* | 62.5f | 73.0c | 79.0a | 81.1a | 71.0d | 68.0c |
| *Uzbek-2* | 59.1d | 61.0d | 66.3b | 69.3d | 60.3d | 64.2c |
| | | | Stem girth (cm) | | | |
| *Yuldus* | 1.00a | 1.10a | 1.24a | 1.05a | 1.10a | Nd |
| *Dustlik* | 0.92a | 1.00a | 1.10a | 1.00a | 1.25a | Nd |
| *Uzbek-2* | 1.00a | 1.00a | 1.10a | 1.18a | 1.16a | Nd |
| | | | No. of leaves/plant | | | |
| *Yuldus* | 37.7b | 37.3b | 46.7a | 36.7b | 33.5c | 33.5c |
| *Dustlik* | 32.6c | 36.8b | 54.8a | 35.8b | 32.9c | 32.7c |
| *Uzbek-2* | 33.8c | 38.9b | 56.8a | 39.0b | 39.8b | 34.9c |
| | | | Plant density (thousand $ha^{-1}$) | | | |
| *Yuldus* | 68.5c | 72.6b | 78.7a | 76.9b | 74.9d | 65.8d |
| *Dustlik* | 54.9c | 60.5d | 68.0c | 70.0b | 72.7a | 68.6c |
| *Uzbek-2* | 75.7b | 77.0b | 79.9a | 80.0a | 70.7c | 68.5d |
| | | | Pod yield (No./plant) | | | |
| *Yuldus* | 65.1d | 68.5c | 98.4b | 106.8a | 60.0c | Nd |
| *Dustlik* | 68.1c | 71.0d | 97.9b | 100.8a | 87.4c | Nd |
| *Uzbek-2* | 105.7c | 111.4d | 124.3b | 152.9a | 115.1c | Nd |
| | | | Grain yield ($t.ha^{-1}$) | | | |
| *Yuldus* | 1.3c | 1.4c | 2.1ab | 3.1a | 1.1c | 1.0c |
| *Dustlik* | 1.3d | 2.3c | 2.9ab | 3.9a | 1.7d | 1.1d |
| *Uzbek-2* | 1.8c | 2.7b | 3.0ab | 4.0a | 2.1c | 1.8c |

Means followed by identical letters horizontally are statistically alike at LSD $\leq$ 0.05 (Ogburia *et al.,* 1999c).



improvement is one of our foremost and humble contributions to Plant Genetics and Breeding Science and a service to humanity.

Vice Chancellor, Sir! Besides some embryological aspects of embryo-sac malformation reported for this genus (Ogburia and Adachi, 1994), there has been no report on the subject. However, this earlier report under explored detail developmental pathways of these reproductive and breeding barriers (irregular megasporogenesis and megagameto-genesis, megagametophyte degeneration, fertilization failure, ovary pathenocarpy, seed abortion and poor germination) at the cellular level. We further examined the developmental pathways of megaga-metophytic reproductive and breeding barriers (fertilization failure, seed abortion and low germination rate) as an appropriate integral component strategy towards the improvement of hybrid seed production in cassava.

Late pre- and post-pollination embryology revealed absence of functional megaspore mother cell (mmc) and megagametphytes respectively. Malformed megaga-metophytes were characterized with reduction in embryo sac volume (8-12.5% of normal), devoid of nucleate cells especially, polar and the antipodal cells, massively vacuolated with no recognizable zygotes or embryos. Regular embryo-sacs commenced degeneration 8days after anthesis in unfertilized ovules of all zero separately pollinated pistils. Degeneration signal initiated from its thin cell wall and transducted radially inwards and outwards to the central cell and the surrounding nucellus respectively. Both integuments (inner and outer) as well as the nucellus of functional (possessing nucleate cells) and non-functional

(devoid of nucleate cells) megagameto-phytes appeared healthy and developed normally. Physical seed analysis showed that phenotypically normal but functionally deprived *pseudo-seeds* (without endosperm and embryo) and *true seeds* are produced at a ratio of approximately 1:2 (Table 5). Two distinct but complemen-tary developmental pathways of fertilization failure, seed abortion as well as poor germination in cassava have been identified (Fig. 4). They are: 1. Ovules devoid of functional megaspore due to lack of megasporocytes during megasporogenesis and 2. Embryo-sacs devoid of nucleate cells due to mitotic inactivity at megagametogenesis resulting in structurally and functionally deprived megagametophyte but morphologi cally normal ovules (Fig. 5). These pathways, either separately or collectively are implicated as largely responsible for the reproductive and conventional breeding barriers in the genus *Manihot* (Fig. 6).





Growth parameters of the varieties, *Dustlik, Yuldus* and *Uzbeskaya-2* responded positively ($P \leqslant 0,05$) to fertilizer application (Ogburia *et al*., 1999). Optimum plant height for all varieties was obtained at 150kgN $ha^{-1}$ level. Number of leaves increased linearly with increase in N rate but declined significantly at N rates exceeding 100kg in all varieties. Plant density declined at 250kgN.$ha^{-1}$. Optimum pod yield was obtained under 150kgN.$ha^{-1}$.Similarly, grain yields significantly as rates increased with optimum yields of 3.1 – 4.0 t.$ha^{-1}$ at 100 and 150 kg (Table 27). Consequently, the optimum N requirement for the three varieties of soybean was 100-150 kg N. $ha^{-1}$ under the experimental conditions of Tashkent, Central Asia thus suggesting hybrids or varieties require fertilization to realize their full genetic yield potentials.

## 7.2 Impact of Fertilization on Crop Varietal Yield Performance

Vice Chancellor, Sir, Soybean (*Glycine max* L. Merrill) is a nitrogen-fixing, protein-rich leguminous crop cultivated for centuries in its center of origin (North-East China) and in South-East Asia (Kogan, 1981). However, protein deficiency in the diets of millions of people in Tropical and Sub-tropical climates is a critical problem in recent decades (NAS, 1984). A meaningful solution to this problem will depend largely on increased yield of protein-rich leguminous crops such as Soybean. In feeding the growing population and in providing greater food security in developing countries, fertilizers have played a leading role in the past and will continue to do so in the future (Baanante *et al*., 1989., Vlek, 1989). This is particularly true in view of the fact the areas likely to be brought under cultivation will need organic and inorganic fertilizers to maintain their yield potential, because the soils of the areas are naturally fragile and new crop technologies, such as improved varieties are fertilizer-intensive, and without fertilizers their yield potential are lower than those of traditional varieties. In order to obtain the full genetic potential of new varieties of soybean adapted to Uzbekistan they must be grown under improved conditions of soil fertility and crop management.

We therefore investigated optimum requirements of three newly bred and released varieties of soybean to Nitrogenous (N) fertilization on a phosphorous background in the continental climate of Tashkent, Central Asia. The rates of N fertilizers were 0, 50, 100, 150, 200 and 250 $kg.ha^{-1}$ as Ammonium Sulphate with a Phosphorous-Potassium fertilizer rate of $120kg.ha^{-1}$ $P_2O_5$ as Single Super Phosphate and $90\ kg.ha^{-1}$ $K_2O$ as Muriate of Potash (MOP).



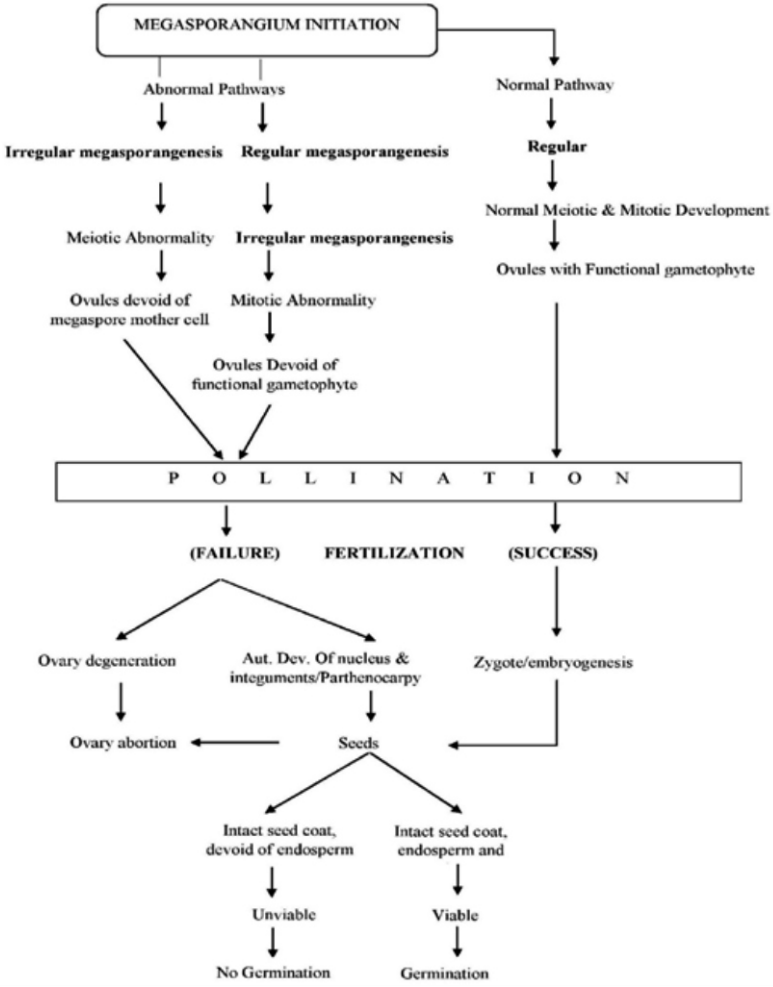


***Fig 4: Schematic representation of development pathways of fertilization failure, seed abortion and poor germination in cassava (Ogburia and Adachi, 1995).***

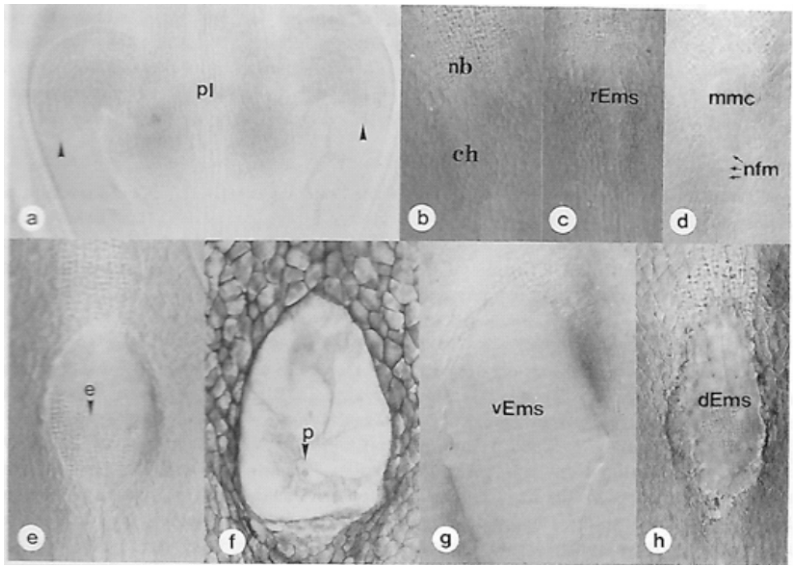


***Fig. 5. DIC and LM micrographs of cleared-pistil and paraffin sectioned ovules of cassava. DIC image of cleared-whole trilocular ovary showing in this focal plane, two pendulous ovular primordia (arrow heads) and the placental axis (pl). X 140 (a). Cleared ovule showing non archesporial or non meiotic ovule at anthesis. X 250 (b). An ovule at anthesis showing a reduced embryo-sac volume (rEms). X 250 (c). A normal ovuleat megasporogenesis showing megaspore mother cell (mmc) with 3 degenerating non functional megaspores (nfm). X 250 (d). A mature embryo-sac at anthesis with one egg nucleus (e). X 250 (e). A LM image of paraffin sectioned mature ovule at anthesis showing one polar nucleus (p). X 250 (f) . A vacuolated embryo-sac (vEms) at anthesis. X 250 (g). A degenerating embryo-sac (dEms). X 250 (h).*** **Source: Ogburia and Adachi, 1995).**





***Fig. 20. Unprepared sucker (note soil and roots), left and prepared (soil and roots removed) and decapitated suckers, right) recommended and ready for planting. Source: Swennen, 1990.***

**Table 26: Effect of sucker treatments on some vegetative parameters in plantain and banana**

| Landrace | Treatment type | Days to emergence (days) | Plant height* (cm) | No. of leaves* | Leaf area ($cm^2$) | *Girth at 25cm (cm) |
|---|---|---|---|---|---|---|
| *Agbagba* | Apical decapitation | 58.0 ± 6.3 | 5.70 ± 10.7[a] | 10.0 ± 3.8 | 2302.8 ± 189.0 | 19.3 0.4[ab] |
| | Corn peeling | 67.0 ± 0.4 | 53.8 ± 8.6[ab] | 11.0 ± 0.0 | 1503.3 ± 211.2 | 15.3 1.6[a] |
| | Apical decapitation + corm peeling | 64.0 ± 2.1 | 48.3 ± 8.6[ab] | 11.0 ± 1.4 | 1746.4 ± 688.4 | 19.0 2.5[ab] |
| | Control | 66.0 ± 2.0 | 55.9 ± 3.6[a] | 10.0 ± 1.5 | 1766.6 ± 296.3 | 17.5 1.6[ab] |
| *Sweet banana* | Apical decapitation | 57.0 ± 9.7 | 48.5 ± 14.9[ab] | 8.0 ± 0.6 | 792.6 ± 241.8 | 15.0 2.5[ab] |
| | Corn peeling | 74.0 ± 7.8 | 66.3 ± 9.9[a] | 8.0 ± 0.6 | 1340.8 ± 682b | 18.3 1.9[ab] |
| | Apical decapitation + corm peeling | 74.0 ± 3.5 | 21.8 ± 12.5[b] | 11.0 ± 1.5 | 580.0 ± 221.2 | 15.0 1.0[b] |
| | Control | 72.0 ± 7.6 | 33.8 ± 12.1 | 8.0 ± 2.4 | 928.2 ± 285.0 | 21.0 0.6[a] |

*at 120 days after planting (Ogburia and Apapa, 2000).

roots and corms. We therefore investigated the establishment and growth of Plantain and Banana suckers after physical treatment involving apical pseudo-stem decapitation and corm peeling (removal of soil and roots from corms) in a humid agro-ecological zone of Nigeria.

This study was carried out at the Rivers State Agricultural Development Programme (RSADP) Area Extension Office Farm, Ahoada, Rivers State, Nigeria which is located on latitude 5.15°N and longitude 6.45°E and on an elevation of 18m above sea level and lies in the humid tropical zone of Nigeria.

Apical decapitation and corm peeling of suckers (Fig. 20) had significant ($P \leqslant 0.05$) effect on plant height. Girth (G.25) depended upon landrace rather than sucker treatment. Apical decapitation and corm peeling of suckers did not significantly ($P \leqslant 0.05$) influence the number of days to emergence of new leaves. However, significant variation in leaf area was observed between the two landraces (Table 26), with cv. *Agbagba* having a larger leaf area (1829.8cm$^2$) than Sweet banana (910.4cm$^2$). Apical decapitation and corm peeling of suckers influenced the establishment and growth of suckers with percentage emergence of 89% plantain (*Agbagba*) and 78% for Sweet banana (Ogburia and Apapa, 2000). Physiological injury response and self-perpetuation instincts are implicated for establishment of the physically treated suckers.



***Table 4: Summary of Embryo sac condition at anthesis in pistils of four Asian cultivars***

| Clone | Ovules Observed | Number of embryo sacs with | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 0- | 1- | 2- | 3- | 4- | 5- | 6- | 7- | 8-Nucleate Cells |
| *Rayong 3* | 191 | 11 | 20 | 0 | 0 | 0 | 30 | 40 | 30 | 60 |
| *Rayong 60* | 191 | 0 | 11 | 0 | 0 | 0 | 0 | 54 | 36 | 90 |
| *Rayong 90* | 191 | 15 | 20 | 0 | 0 | 0 | 0 | 33 | 44 | 79 |
| *CMR 25-105-112* | 190 | 5 | 31 | 0 | 0 | 0 | 0 | 50 | 15 | 89 |
| Total | 763 | 31 | 82 | 0 | 0 | 0 | 30 | 177 | 125 | 318 |
| Mean | | 0.04 | 0.11 | 0 | 0 | 0 | 0.04 | 0.23 | 0.16 | 0.4 |

Based on the number of Identified nuclei of the egg apparatus, polar and antipodals cells only (Ogburia and Adachi, 1995)

***Table 5: Simple physical analysis of cassava seeds and percentage germination obtained from three crosses and one OP plants harvested in November, 1993.***

| Cross | Quantity tested | Weight[a] (g) | | Water floatation | | % Seed germination | ratio[c] ts : fs |
|---|---|---|---|---|---|---|---|
| | | Normal | Abnorml | Settle | Floated | | |
| *Rayong 90 x Rayong 90* | 592 | 13.1 | 5.8 | 370 (62.5) | 220 (37.2) | 40.5 | 2 : 1 |
| *Rayong 60 x Rayong 3* | 600 | 11.6 | 7.1 | 366 (61.0) | 234 (39.0) | 8.0 | 2 : 1 |
| *Rayong 3 x Rayong 3* | 299 | 12.2 | 6.0 | 201 (67.2) | 98 (32.8) | 67.5 | 2 : 1 |
| *CMR 25-105-112' (OP)* | 422 | 11.6 | 7.1 | 272 (64.5) | 150 (35.5) | 25.5 | 2 : 1 |

a = data indicates mean weight of 100 seeds replicated 2 times. b = % seed germination of 200 seeds per cross. c = approximate ratio of true seed (ts) to false seed (fs). Figures in parenthesis represent percentage of 'settled' and 'floated' seeds respectively (Ogburia and Adachi, 1995).

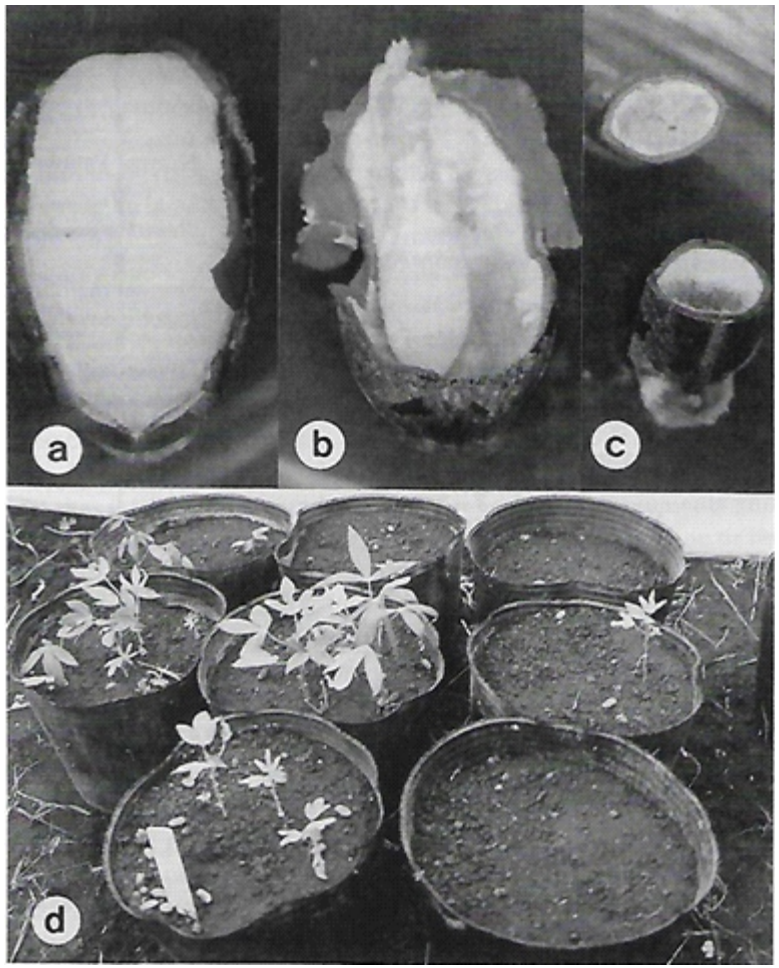


***Fig. 6. Physical examination of cassava seeds. A normal true seed showing the storage endosperm and embryonic axis (a). A pseudo-seed with partial storage endosperm and embryonic axis (b). A pseudo-seed with complete lack of endosperm and embryonic axis (c). Sporadic and poor germination of cassava seeds (d). Source: Ogburia and Adachi, 1995.***





***Table 25: Effect of planting method on tuber yield of cassava clones***

| Planting Method | Number of tuber per clones | Fresh tuber weight per clones (kg/0.056ha) |
|---|---|---|
| Angle | 2.55b | 6.94a |
| Horizontal | 4.34a | 5.22b |
| LSD (0.05<=P) | 0.36 | 1.05 |

Means followed by different letters within a column are significantly different P = 0.05 (LSD) (Ogburia and Okele, 2003).

## 7.1 *In-situ* Apical Decapitation and Establishment in Plantains and Bananas

Vice Chancellor, sir! Plantains and bananas are grown successfully on a wide range of soils but do best on silty-clayed soil that is rich in organic matter. They tolerate acid soils (5.0-6.5). Botanically, they are describes as large perennial herbaceous plant which consist of an underground stem known as corm. The corm bears eyes on it middle and upper parts, which develop into suckers. They are propagated mainly vegetatively by suckers. The type of suckers include, peepers, sword, water, maiden and bits. In our traditional farming system, farmers often collect plantain or banana suckers of any type plant directly into the soil without any form of physical or chemical treatment of the propagules. This often results in re-introduction of infections into new plantations or homesteads (backyards). Nematodes, stem borers and other diseases and pests result in low productivity and consequent low income for the rural farmers. Again, the incidence of lodging is increased with the slightest windstorm as a consequence of nematode infection of the

agronomic research has not been done in this area. Therefore, we (Ogburia and Okele, 2000) investigated angle and horizontal plant methods for vegetative and agronomic performance of selected cassava hybrids of the TMS series developed by IITA in a humid agro-ecological zone of Nigeria.

Vegetatively, time of sprouting did not differ significantly ($\leqslant$ 0.05) among the cassava clones and between angle (45-60$^{o}$) and horizontal plant methods. Developmental stage had effect on plant height and number of leaves during vegetative growth period. Clone *TMS 87/00611* had the tallest plants (76.2 cm), while *TMS 4(2) 1425* was 43.4 cm tall at 24 WAP. Angle planting produced taller (53.9 cm) plants than horizontally buried method (50.6 cm). Number of leaves per plant per cultivar was greater in *TMS 30555* (67 leaves/plant) and lowest in the local control cultivar – *Wocha* (27 leaves/plant). Number and fresh weight of tubers were significantly different among the cultivars as well as between planting methods (Table 25). Number of tubers per plant per clone was highest in *TMS 30555* (4 tubers/plant) and least in *TMS 91/0061* (2.9 tubers), 4.3 tubers in horizontal method and 2.5 tubers in angle method (Ogburia and Okele, 2000). Fresh tuber weight was highest in *TMS 84/00275* and least in *TMS 4(2)1425* and in angle method than in horizontal. For optimum tuber weight, angle method was superior to horizontal and thus could be adopted in cassava production in a humid agro-ecology (Ogburia and Okele, 2000).



## 4.2 Sexual Bilateralism of Polyploidization in Cassava

Vice Chancellor Sir! Cassava is the second most important tuber crop in the world after potato. It is vegetatively propagated and grown primarily for its starchy tuberous roots and sometimes for the leaves in many tropical countries of the world, particularly in Africa. It is a major and integral component in our cropping systems in Nigeria (Anyaegbu *et al*., 2008a) where it is intercropped with other weed suppressing crops (Anyaegbu, *et al*., 2008b), which enhance soil fertility and minimize the risk of total crop loss. Efforts aimed at breeding cultivars with high protein content, among other important agronomic traits, are fraught with numerous problems, including sexual reproductive barriers. The formation of (*2n*) gametes is a common phenomenon in angiosperms (de Wet, 1980), which most likely play a major role in the evolution of polyploidy series (Harlan and de Wet, 1975: Jackson, 1976). Until now there have been no cytogenetic or histological reports on the occurrence of megaspores with *2n* eggs or bilateral sexual polyploids in cassava. The objective of this work was to investigate the probable existence of bilateral sexual polyploidization as an integral breeding strategy in cassava using the standard cytogenetic methods reported elsewhere (Ogburia and Adachi, 1994; Ogburia, 1995).

At telophase II, formation of 17-21 micro-nuclei per pollen cell plate was observed in 16 out of 351 cell plates in *M. mga.* Micro-nuclei were observed at low (0.3-2.3%) frequencies at the sporad stage in all clones. Monads, dyads, triads and tetrads, which are established sources of high ploidy levels were observed at low (2.6%) and high (22.2%) frequencies

(Fig. 7, Table 6). Megasporogenesis in *Rayong 1* and *Rayong 60* showed a lack of second meiotic (MII) division after a successful first (MI) division that resulted in partly unreduced embryo sac with *2n* eggs, suggesting another unrecognized and, as yet, unreported source of sexual polyploidy formation in cassava. Meiotic abnormalities during microsporogenesis (Ogburia, 1999) and megasporogenesis are implicated as being responsible for the formation of mixoploids (triploids and tetraploids) in cassava breeding programmes. A cytogenetic mechanism resulting in bilateral sexual polyploids through different gametic fertilization pathways in cassava is advanced and its role in breeding is advocated (Ogburia *et al.,* 2002). Therefore, cassava plants with higher ploidy levels evolved through unreduced embryo sacs or unreduced pollen grains as shown in Fig. 8.

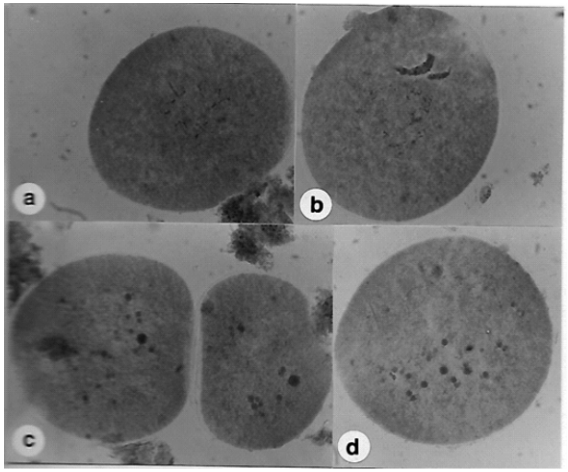


***Fig. 7. 1. Microsporogenesis. Chromosome asynapsis and micro-nuclei formation in cassava x 250, a-b asynapsis (no pairing of chromosomes), c-d micro-nuclei at Telophase II.***





season (Table 24). Seed yield hectare$^{-1}$ was highest in POM in both seasons (Davids *et al*., 2004).

***Table 24: Agronomic response of groundnuts during the late season (1997)***

| Fertilizer Type / Trait | Plant Height at 55 DAP (cm) | No. of branches 55 DAP | No. of Leaves at 35 DAP | No. of Leaves at 85 DAP | Haulm yield at 65 DAP (kg) | No of Pods per plant | No. of Seeds per pod | Weight of 100 seeds | Weight of shells t/ha | Shelling percentage | Weight of Grains t/ha |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 (Control) | 26.3 | 9.0 | 386.0 | 548.5 | 58.9 | 14.5 | 1.5 | 33.8 | 2.3 | 50.8 | 1.8 |
| PIG | 26.9 | 10.7 | 452.4 | 687.0 | 75.7 | 18.5 | 1.7 | 33.8 | 3.3 | 43.3 | 1.9 |
| PBA | 32.7 | 11.3 | 455.4 | 633.5 | 100.6 | 22.0 | 1.7 | 34.9 | 4.0 | 34.3 | 2.0 |
| POM | 32.9 | 10.7 | 467.4 | 683.5 | 97.2 | 30.0 | 2.0 | 37.4 | 3.9 | 39.3 | 3.2 |
| NPK | 27.4 | 10.0 | 401.7 | 599.0 | 87.6 | 25.5 | 1.9 | 39.6 | 5.0 | 41.0 | 3.1 |
| MEANS | 29.6 | 10.3 | 432.6 | 630.2 | 84.0 | 22.1 | 1.8 | 35.9 | 3.7 | 41.7 | 2.4 |
| L.S.D 0.05 | 2.4 | 2.1 | 96.9 | 125.3 | 34.3 | 8.5 | 0.6 | 8.5 | 2.1 | 8.7 | 1.3 |
| L.S.D 0.01 | 4.4 | 3.1 | 142.7 | 184.4 | 50.5 | 12.4 | 0.7 | 12.5 | 3.2 | 12.8 | 1.8 |

(Davids *et al.,* 2004).

Vice Chancellor, sir! The agronomic and cultural practices of cassava production are well documented (Ekanayake *et al*., 1997). Cassava cuttings may be planted upright vertically, or at an angle in the soil or horizontally beneath the soil (IITA, 1990). However, there is paucity of information on the yield differences between angle and horizontal methods of planting of the stem cuttings. Angle and horizontal plantings have been recommended for regions of high and low rainfall (Zuofa and Onuegbu, 1994) with no specific mention of reference cultivars. More information on varietal yield performance of developed hybrids in various agroecological zones are urgently needed to formulate appropriate production technology package for each zone. Enough

Furthermore, Orluchukwu and Ogburia (2014) evaluated the relationship of growth and yield components of different plantain landraces and hybrids in a humid agro-ecological zone of Nigeria. Growth components showed that plant height and number of leaves at flowering were positively correlated and followed by number of suckers at harvest. For yield components, number fingers and hands negatively correlated with number of suckers and bunch weight. The results further revealed that growth parameters alone can predict yield potential of up to 72% in the genus, *Musa*.

Vice Chancellor, Sir! Groundnut (*Arachis hypogaea* L.) also known as peanut in USA is a native of South America but grown throughout the six continents of the world (McGill, 1973). It is an indeterminate day-neutral $C_3$ plant (Barbour *et al*., 1974). Groundnut could be processed and utilized in various ways as food, groundnut butter, oil flour, in confectioneries and even in livestock farms and crop farms. In farms, the foliages provide silage for cattle and the cake as fathering material for farm animals (Nnadi and Hague, 1988). Optimum production of groundnut is hampered by numerous factors; prominent of which includes production processes, poor agronomic practices and soil fertility problems.

We investigated the effects organic manure sources (Poultry manure – POM, Palm bunch ash – PBA, Piggery manure – PIG and inorganic (NPK 20:10:10) fertilizers at 0, 400kg $ha^{-1}$ on the agronomic parameters of two morpho-types of groundnut in early and late seasons of our farming system. In both seasons, groundnut plants were tallest in the PBA, NPK and POM treatments. Weight of shells was highest with NPK in late planting season and with PBA in the early planting



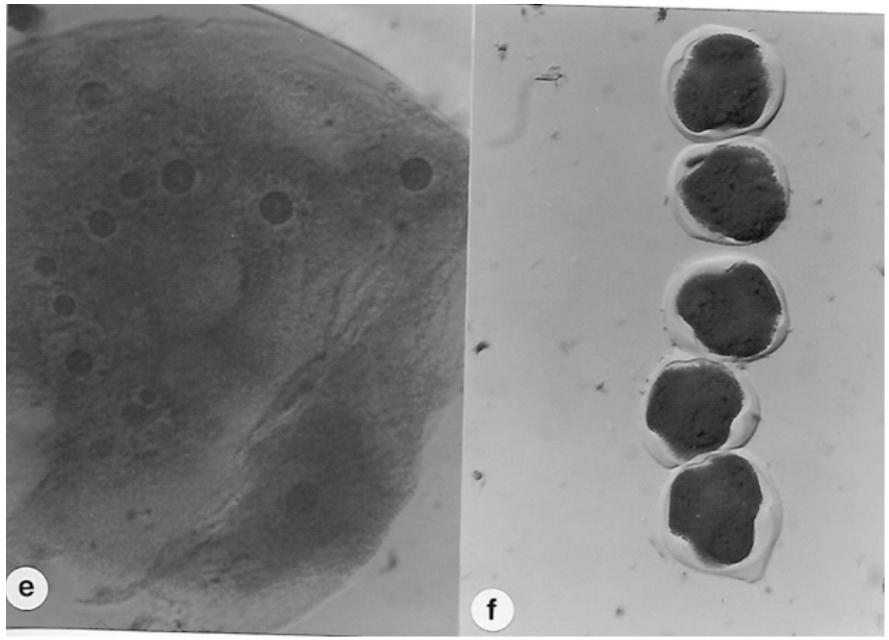


***Fig. 7. 2. e-f. Microspore irregularities continued, e- an enlarged TII cell plate showing 16 micro-nuclei x 500. f- simultaneous cytokinensis, x 250.***

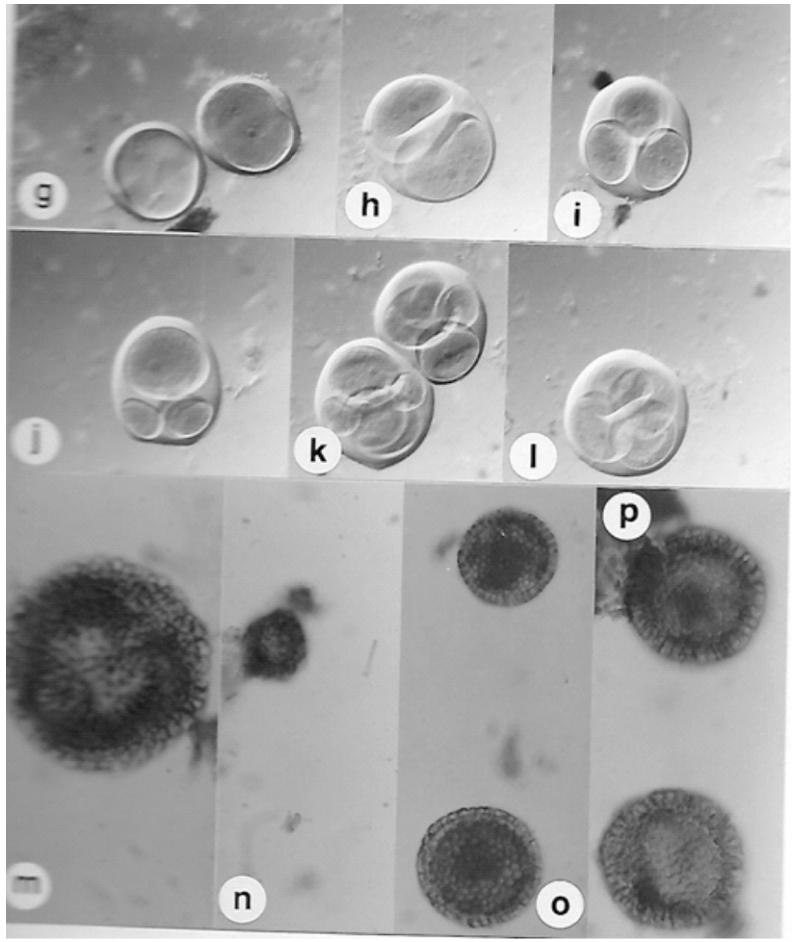


***Fig. 7. 3. Unreduced and reduced microspores (x250) and mature pollen size variations (x 500), 'g' unviable and viable monad association, 'h' dyad, 'i' tryad, 'j' monad with 2 micronuclei, 'k' tryads with 1 and 2 micronuclei each, 'l' normal tetrad, 'm' jumbo-pollen, 'n' near average-sized pollen, 'p' normal sized pollen. Source: Ogburia, 1996).***





Table 23: Phenology, growth, yield and yield components of secondary triploids *Musa* hybrids (AAB) group.

| Clone | N | Phenology | | | | Growth Characteristics | | | | | Yield Performance | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | DEL | DFF | DTH | PHT | PGT | TNL | YLSF | NSLF | INSL | HTS | BWT | NHD | FIN | FL | FC |
| | | Days | Days | Days | cm | cm | No. | | | | cm | kg | No. | No. | cm | cm |
| Plantain hybrids | | 283 | 101 | 384 | 359 | 66 | 37 | 7 | 9 | 65 | 194 | 20.5 | 11 | 201 | 21.4 | 12.0 |
| 25344 – 18 | 11 | 276 | 113 | 389 | 305 | 46 | 34 | 7 | 8 | 67 | 354 | 6.6 | 9 | 200 | 10.1 | 7.3 |
| 2525281 - 1A | 10 | 254 | 112 | 366 | 312 | 46 | 34 | 7 | 8 | 65 | 366 | 3.3 | 8 | 143 | 12.9 | 6.9 |
| 25257 - 11B | 10 | 300 | 91 | 391 | 368 | 61 | 38 | 9 | 10 | 72 | 405 | 11.1 | 8 | 130 | 15.6 | 10.4 |
| 25502 - S4 | 12 | 400 | 101 | 501 | 351 | 61 | 40 | 7 | 9 | 66 | 368 | 8.4 | 8 | 183 | 13.4 | 8.9 |
| 25320 – 3 | 10 | 307 | 93 | 400 | 351 | 60 | 39 | 7 | 8 | 68 | 328 | 6.2 | 8 | 116 | 13.2 | 8.9 |
| 25333 - S66 | 11 | 283 | 119 | 402 | 381 | 61 | 38 | 8 | 9 | 71 | 431 | 10.5 | 7 | 105 | 16.5 | 11.7 |
| 25333 - S88 | 10 | 405 | 113 | 518 | 377 | 63 | 41 | 7 | 8 | 63 | 253 | 9.7 | 7 | 140 | 15.2 | 10.2 |
| 25729 – 5 | 6 | 387 | 106 | 493 | 336 | 64 | 40 | 8 | 10 | 69 | 311 | 10.9 | 7 | 139 | 19.2 | 10.8 |
| 7152 - 2OPS15 | 9 | 270 | 129 | 399 | 331 | 48 | 36 | 10 | 11 | 74 | 402 | 7.5 | 5 | 94 | 16.4 | 10.3 |
| A5SPS548 – 9 | 11 | 235 | 116 | 350 | 310 | 58 | 34 | 8 | 10 | 70 | 333 | 9.9 | 5 | 84 | 18.3 | 13.6 |
| A10SPS548 – 9 | 8 | 241 | 93 | 334 | 332 | 61 | 30 | 9 | 11 | 71 | 326 | 12.8 | 5 | 90 | 18.8 | 12.5 |
| Checks | | | | | | | | | | | | | | | | |
| 15108 – 6 | 12 | 255 | 124 | 375 | 315 | 70 | 38 | 6 | 8 | 64 | 338 | 14.6 | 8 | 152 | 15.4 | 11.77 |
| 7152 – 2 | 10 | 245 | 109 | 354 | 314 | 59 | 35 | 9 | 11 | 72 | 327 | 7.9 | 7 | 87 | 17.3 | 11.1 |
| 5295 – 1 | 11 | 199 | 82 | 281 | 333 | 63 | 34 | 8 | 9 | 66 | 292 | 13.9 | 9 | 119 | 19.6 | 11.1 |
| Plantain landraces | | | | | | | | | | | | | | | | |
| Agbagba | 8 | 341 | 86 | 427 | 378 | 64 | 41 | 8 | 10 | 68 | 337 | 8.6 | 7 | 31 | 25.7 | 15.4 |
| Obino l'ewai | 9 | 356 | 94 | 450 | 376 | 61 | 40 | 6 | 8 | 63 | 281 | 8.9 | 7 | 87 | 17.9 | 11.9 |
| LSD 0.05 | | 42.4 | 22.3 | 36.8 | 24.9 | 4.2 | 3.2 | 1.2 | 1.3 | 6.5 | 37.5 | 2.5 | 0.9 | 22.4 | 2.1 | 1.2 |
| C. V (%) | | 15.9 | 9.6 | 10.0 | 8.2 | 8.1 | 7.2 | 17.4 | 14.7 | 10.9 | 12.2 | 24.4 | 16.3 | 21.4 | 13.8 | 12.2 |

DFL = Days to flowering; DFF = Days to fruit filling; DTH = Days to harvest; PGT = Plant girth at flowering; YLSF = Youngest leaf spotted at flowering; NSLF = Number of standing leaves at flowering; INSL = Index of non-spotted leaf; HTS = Height of tallest sucker at flowering; BWT = Bunch weight; HND = Number of hands; FIN = Number of fingers; FL = Fruit length; FC = Fruit circumference (Shaibu *et al*., 2003).

characters were significantly different ($P \leqslant 0.05$) for phenology and yield performance among the *Musa* genotypes investigated. All hybrids were shorter than the plantain landrace checks. Hybrid *25344-18* (secondary triploid) derived from 7152-2 x 9128-3 had significantly heavier bunch weight (20.5kg) than the other hybrids and checks (Shaibu *et al*., 2003). Yield component analysis revealed that bunch weight largely depended on large fruit, number of hands, fruit length and fruit length and fruit circumference.

Similarly, we also evaluated yield of plantain and banana landraces and hybrids in farmers' production system in the humid agro-ecological zone of Nigeria. The analysis of variance test of significance revealed that bunch yield per producing plant was highly variable and was statistically significant across genotypes and within replicates (Shaibu *et al*., 2012). The hybrids were more suitable for the agro-ecology as most of the hybrids (*FHIA 21, SH 3436-9sv* and *SH 3640*) performed exceedingly better in bunch weight compared to other hybrids and landraces. This study determined the best yielding genotypes and the components of yield in the 36 genotypes investigated (Table 23).



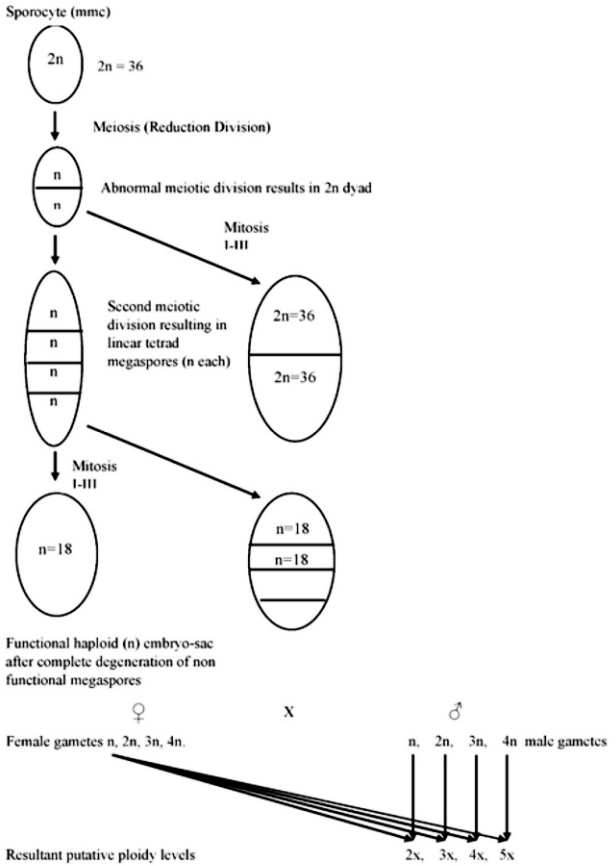


***Fig. 8: Schematic representation of abnormal megasporogenesis and evolution of sexual polyploids in cassava, Manihot esculenta Crantz. (1) Functional 2n dyad formation due to failure of second meiotic division. It could result in polyploids as follows; (2n + n = 54 = 3x, 2n + 2n = 72 = 4x and so on), assuming the false micropylar or nucellar beak embryo-sac is fertilized and the other embryo sac degenerates later. (2) Formation of two haploid (n) embryo-sacs due to incomplete (two instead of three) tetrad megaspore degeneration. This could result in polyploids, e.g. n + n = 36 = 2x, n + 2n = 54 = 3x etc. (Ogburia et al., 2002).***

Such mixoploids are recognized for their superiority in productivity over diploid cassava clones. Furthermore, higher ploidy levels resulting from diploid crosses (2*n* x 2*n*) could be of immeasurable breeding value because of the potential enhancement of genetic diversity, which is a prerequisite for genetic studies as well as for genetic improvement in the genus. The introgression of desirable genes for low cyanide content, and disease and pest resistance from 2*n* wild *Manihot* in a breeding programme is a conventional breeding method used by breeders at the International Institute of Tropical Agriculture (IITA) as documented by Hahn *et al*., 1990 and Ng *et al*., 1992.

**Table 6: Cyto-genetical characteristics of five cassava clones and $F_1$ hybrids at the sporad stage of microspore development based**

| | Cultivars (n = 4) | | | Hybrids (n = 5) | |
|---|---|---|---|---|---|
| | *Rayong 1* | *Rayon 60* | *M. mga* | *OMR 36-41-1* | *OMR 36-42-4* |
| Monad | 60 (19.7) | 37 (10.5) | 28 (8.0) | 11 (3.1) | 9 (2.6) |
| Dyad | 20 (5.7) | 43 (12.3) | 39 (11.1) | 78 (22.2) | 16 (4.6) |
| Triad | 51 (14.5) | 19 (5.4) | 9 (2.6) | 47 (13.4) | 24 (6.8) |
| Tetrad with: | | | | | |
| One Micronucleus | 3 (0.9) | 0 (0) | 7 (2.0) | 3 (0.9) | 1 (0.3) |
| Two Micronuclei | 4 (1.1) | 2 (0.6) | 8 (2.3) | 6 (1.7) | 6 (1.7) |
| Three Micronuclei | 4 (1.1) | 0 (0.0) | 0 (0.0) | 1 (0.3) | 6 (1.7) |
| ≥15 Micronuclei | 0 (0.0) | 0 (0.0) | 4 (1.1) | 0 (0.0) | 0 (0.0) |
| Pollen stainability (%) | 84.30 | 85.80 | 60.10 | 56.10 | 97.20 |

**Data based on 351 sporads observed per clone, n- number of observed plants per clone (Ogburia *et al*., 2002).**





around Niger River in the Delta area. Infact, *Oryza glaberrima* is indigenous to Nigeria and it has been in cultivation for over 3,500 years ago (NCRI, 1997., WARDA, 2004). Variability among rice genotypes in their floral behavior due to genetic disparity, interaction between genotype and environmental component other than soil salinity have been well established by scientists and agronomists from different rice growing regions of the world. However, there is paucity of information concerning the phenology of rice hybrids grown in a tidal saline mangrove environment in wet and dry seasons. Consequently, the aim of this investigation was to evaluate the flowering behavior of 10 swamp rice hybrids for enhanced rice improvement strategies in a tidal saline mangrove soil environment of Nigeria. Soil salinity and days to 50% panicle initiation and 50% flowering were negatively correlated ($r$= -0.458 and $r$= -0.459) respectively for hybrid *BW 348-1* only out of the 10 hybrid cultivars. Generally, floral performance was better in wet than dry season probably due in part to less salinization of the soil solution as a result of dilution (Ogburia *et al*., 2007). Average seasonal salinity in excess of 1290µs/cm - 2580µs/cm during the dry season hastened days to 50% panicle initiation, 50% flowering, and maturity period of some cultivars, which had negative impact on paddy and grain yield. Flowering stage is the most critical stage to the Rice Breeder in a hybridization process. Increase in salinity increases level of floret sterility (empty spikelet per panicle).

Vice Chancellor, sir, we evaluated thirteen (13) hybrids derived from 4n x 2n cross and three (3) checks for phenology, growth and agronomic characteristics in a humid agro-ecological zone of Nigeria. Fifteen (15) phenotypic

**Table 22: Effect *of Inga edulis, Dactyladenia barterii and Anthonatha macrophylla* leachates on germination and seeding growth of maize cv. local white***

| Character Attribute | *Inga leachate* | *Dactyladenia leachate* | *Anthonatha leachate* | Rain water |
|---|---|---|---|---|
| Germination (%) | 44.3c | 50.0b | 33.0d | 76.7a |
| Radicle length (cm) | 1.7b | 1.5b | 0.9b | 3.3a |
| Shoot length (cm) | 7.0b | 9.2b | 5.1c | 11.6 |
| Fresh weight (g) | 13.2b | 15.0b | 8.9c | 21.5a |
| Plant height at tasselling (m) | 1.9a | 1.8a | 1.6a | 2.4a |

*Mean values with identical letters within a row are not statistically different at P<0.05
a. Radicle length at the end of germination (7days)
b. Shoot length at the end of germination (7days)
c. Fresh weight at 21 days after sowing (Adeorike *et al.,* 2011).

Similarly, Ikpe *et al*., (2009) assayed the effects of cassava processing effluents on soil properties, growth and yield of maize in Southeastern Nigeria. Again, Orlu Chukwu and Ogburia (2006), evaluated agronomic performance of Okro and cowpea under oil palm sludge and found enhanced performance and sun pressed weed infestation.

Mr. Vice chancellor, sir, Rice (*Oryza* sp,) is tolerant to desert, hot humid, flooded dry and cold conditions and grows on saline, alkaline and acidic soils (AgricNews, 2003). Out of about 23 *Oryza* species identified, only 2 are successfully cultivated. The two cultigens include *Oryza sativa* L. which originated in the humid tropics of Asia (South and Southeast Asia), and *Oryza glaberrima* Steud, from West Africa,



***4.3.1 Breeding for Apomixis in Cassava and Plantain/ Banana -*** Vice Chancellor, Sir. Apomixis, the asexual seed production without the fusion of male and female gametes provides a novel tool for breeding elite cultivars of genetic identity with the female parent even though it has also been identified as a breeding barrier (Jefferson, 1993., Nakagawa *et al*., 1993). Transfer of apomixis by hybridization to cultivated crops from apomictic relatives has been suggested (Bashaw, 1980., Dujardin and Hanna, 1985) because it offers potentials for conservation of heterozygosity and fixation of heterosis (Jefferson, 1993., 1994).

***4.3.2 Apomixis in Cassava (Manihot esculenta Crantz) -*** zHeterozygosity in cassava and vegetative propagation with concomitant disease dissemination justifies breeding for apomixis. Fundamentally, if successful breeding for apomixis is to be achieved, identification of source of gene(s) for apomixis from wild relatives, derivative hybrids and among cultivated landraces will constitute a pre-requisite. Information on floral biology of cassava exist (Chandraratna and Nanayakkara, 1948., Capinpin and Bruce, 1955., Kawano, 1980., IITA, 1990., Hershey, 1993). Unfortunately, however, there is little information on the embryology of cassava (Graner, 1935., Rao and Rao, 1976., Ogburia and Adachi, 1994a., b., 1995). Up to now, however, there is no cyto-histological report on the reproductive mechanism resembling apomixis in cassava. The aim of this study was to cyto-histologically examine a number of Asian cultivars to determine if any, the type and degree of apomictic gene potential in cassava. We also used the conventional sectioning technique because the former is not cell- or organelle-specific (Mol *et al*., 1994).

All the six clones were found to possess one single sexual embryo-sac containing 6-8 nuclei at maturity. However, one clone *Rayong 3* possessed 2 functional embryo-sacs at 12 hours after controlled pollination (HACP). The larger embryo-sac was 6-nucleated (all 3 nuclei of the egg apparatus, 1 polar and 2 antipodal cells) and located towards the false micropylar or the nucellar beak region. The smaller embryo-sac also contained a total of 6 nuclei and approximately $10\mu m^3$ or $^1/_2$the volume of the former and located towards the chalazal pole (Fig). Percentage sexuality estimates indicated 100% sexual reproduction in embryo-sacs of all the clones studied. However, apomeiotic relationships indicated a low (0.3%) degree of meiotic diplosporous embryo-sac formation, thus suggesting facultative apomixis in cv. *Rayong 3* (Table 7). This is the first cytogenetic identification and evidence of apomeiosis and apomictic gene potential in cassava (Ogburia and Adachi, 1996).





having a direct or indirect detrimental chemical effect on another (receptor) plant through the production of allelochems is called allelopathy (Rice, 1974). We evaluated the allelopathic influence of selected multi-purpose tree species (MPTs) on Maize (*Zea mays* L.) under a simulated field condition (Adeorike, *et al*., 2001).

Germination and growth response of Maize that was periodically watered with 200ml of leaf leachates of three MPTs – *Inga edulis*, *Anthonatha macrophylla* and *Dactyladenia barterii* were assayed to determine their allelopathic characteristics and suitability for alley cropping. There was a significant ($P \leqslant 0.05$) difference in the germination percentage of the maize seeds among the MPTs studied. Maximum germination percentage (76.7%) of the seeds and seedling growth as indicated in by radical length, shoot length, fresh weight and plant height at taselling were obtained from seeds watered with rainwater as the control treatment. Reduction in germination percentage (33%) was observed in *Anthonatha macrophylla* leachates while moderate germination percentage of 50% was observed in *Dactyladenia barterii* leachates (Table 22). *Anthonatha macrophylla* leachates inhibited both radical and shoot length. Similarly, *Inga edulis* leachate had inhibitory effects on radical and shoot of germinating maize seeds. Our results suggest that *Inga edulis*, *Anthonatha macrophylla* and *Dactyladenia barterii* produce allelochems which inhibit seed germination and growth of maize under the environmental condition of the experiment. Furthermore, investigations on allelopathic characteristics of potential MPTs could be integrated in plant breeding strategies in a tropical agro-ecology especially where alley cropping is contemplated because growth and developmental architecture of many plants such as maize in an allelopathic environmental field condition could also be attributed to genetic components (Adeorike *et al*., 2001).

## 7.0 AGRONOMY (ENVIRONMENTAL COMPONENT) IN PLANT BREEDING

Vice Chancellor, Sir! Plant breeding or Hybridization (making crosses between chosen plants) is executed in a given environment. Again, obtained hybrids would also be subjected to different environmental variables. Agronomy and or cultural practices of crop production exemplifies an environmental component of Applied Genetics or Plant Breeding as previously expressed by the formula, P = G x E in the foregoing. The traditional agro-technic of shifting cultivation and related bush-fallow systems have for generations provided resource-poor farmers with an efficient and stable food production system in the absence of purchased inputs (Sanchez and Salinas, 1981). When land becomes limiting and fallow periods are shortened so that adequate nutrient levels are no longer restored, the system deteriorates (Anarson *et al*., 1982). In recognition of this and knowing the importance of deep rooted trees and shrubs in nutrient recycle; scientists at the IITA have developed alley cropping which involves growing annual food crops in alleys between hedgerows of trees/shrubs (Kang and Wilson, 1987). This is an advanced form of agro-forestry. Hedgerows are periodically pruned to prevent excessive shading of food crops and to supply green manure and mulch. The practice is increasingly becoming accepted as a cropping system with the potential to provide stable and sustainable food production (Atta-Krah *et al.,* 1985; Torres, 1983). If alley cropping (Kang *et al*., 1984) is to be considered as an alternative to shifting cultivation, then it becomes imperative to evaluate the compatibility of pruned hedgerow species with major food crops such as maize. In addition to competing for light, water and minerals, plants can inhibit seed germination and growth of neighboring plants by releasing a variety of toxic chemicals, called allelochems (Rice, 1974). The phenomenon of one plant (donor)



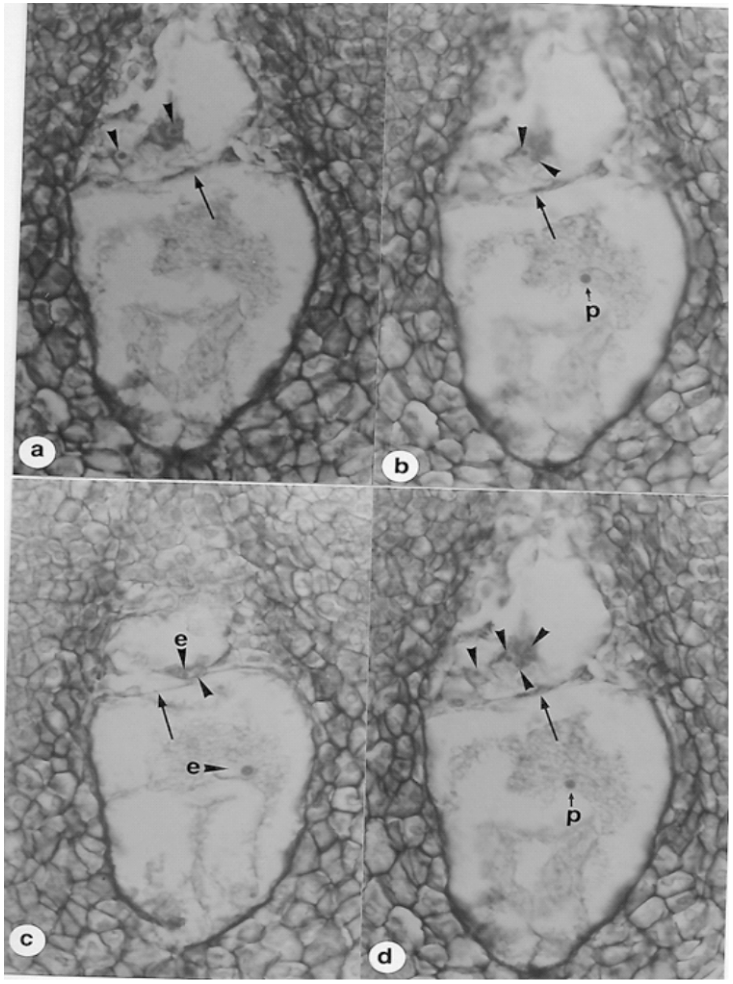


***Fig. 9. Longitudinal section of multiple embryo-sac of cassava, cv. Rayong 3, x 500. (a) LM image of multiple embryo-sac (chalazal and nucellar) showing 2 nuclei of the chalazal embryo-sac (arrow heads) and cell wall (arrow) demarcation from the nucellar beak embryo-sac, (b) same embryo-sac in a different focal plane showing another 2 nuclei of the chalazal embryo-sac and 1 polar nucleus (p), (c) egg nuclei of both embryo-sacs, (d) Different plane showing all 4 nuclei.***

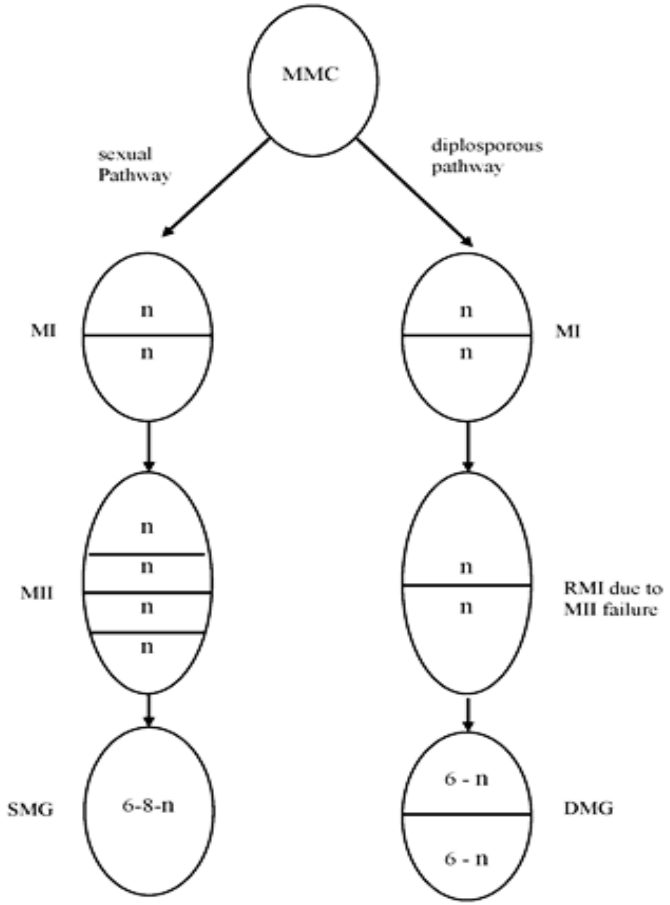


***Fig 10. Developmental pathway of diplosporous embryo-sac formation in Casava MMC = Megaspore Mother Cell. MI = Meiosis I, MII = Meiosis II, SMG = Sexual megagametophyte, RMI = Reconstituted meiosis I (mitotic process in both embryo-sacs as both nuclei do not join to form one embryo-sac), DMGs = Diplosporous megagametophytes, n = number of nuclei per embryo-sac (Ogburia and Adachi, 1996).***





**Table 21: Seed Production after Open pollination (OP) and Artificial Production (AP)**

| Cassava clones | No. of seeds per ovary | | No. of seeds per clone | |
|---|---|---|---|---|
| | OP | AP | OP | AP |
| *TMS 82/00058* | 0.00 | 0.00 | 0.00 | 0.00 |
| *TMS 84/00275* | - | - | - | - |
| *TMS 30572* | 2.00 | 1.75 | 43.50ab | 9.75b |
| *TMS 4(2) 1425* | 1.20 | 0.89 | 12.00b | 4.25b |
| *TMS 87/00611* | 2.90 | 2.06 | 40.63ab | 10.00b |
| *TMS 4488* | 1.90 | 1.59 | 26.88b | 5.88b |
| *TMS 91/00153* | - | - | - | - |
| *TMS 30555* | 2.30 | 2.43 | 65.50a | 31.38a |
| *TMS 91/00061* | 0.00 | 0.00 | 0.00 | 0.00 |
| *Wocha* | - | - | - | - |
| CM | 1.53 | 1.25 | 26.93 | 8.75 |
| LSD (0.05⩾P) | NS | NS | 31.38 | 12.06 |

(Ogburia and Okele, 2001).

Means with different letters in the same column differ significantly, using LSD (P ⩾ 0.05). Cultivars with a dash (-) denote non flowering, while those with 0.00 means were cultivars that exhibited 100% flowering abortion. NS = non significant (Ogburia and Okele, 2001).

Vice Chancellor, sir! The formulation of appropriate hybridization strategies could surmount some of the highlighted reproductive barriers and an effective pollination system could lead to the development of new cassava cultivars with combined traits of high yield, wider ecological adaptation, a reasonable level of protein content and resistance to major pests and diseases (CIAT, 1974., 1975., and 1976). We therefore investigated different cassava cultivars for hybrid seed set efficiency under natural (open pollination) and artificial pollination in the Teaching and Research Farm, Rivers State University - a humid agro-ecological zone of Nigeria.

The time to 50% flowering and the number of pistillate and staminate flowers showed significant variation ($P \geqslant 0.05$) in the study. More staminate than pistillate flowers were produced in all the clones at a ratio of 8:1 = staminate : pistillate per clone. Hybrid seed production was significantly different in the ten selected clones of cassava after natural and artificial pollination (Table 21). Natural pollination was more effective as regards the rate of seed set (26.9 seeds/0.056 $ha^{-1}$, equivalent to 480.9 seeds/ $ha^{-1}$) than artificial pollination, which produced 8.8 seeds/0,056 $ha^{-1}$ or a calculated equivalent of 156.3 seeds/$ha^{-1}$ (Ogburia and Okele, 2001) For optimal hybrid seed production, natural pollination using male sterile females and desirable male fecund parents, well arranged in the field to encourage effective natural pollination, either by wind or insects, is suggested for increased hybrid seed production in a cassava breeding programme in a humid agro-ecological zone of Nigeria.



**Table 7. Distribution of sexual and apomeiotic embryo-sac in a suspected apomeiotic cv. *'Rayong 3'* ovules**

| Clone | Ovules observed | No. of ovules with a | | | | Sexuality[b] | Apomeiotic tendency |
|---|---|---|---|---|---|---|---|
| | | S | D | A | Ab | | |
| *Rayong 3* | 378 | 367 | 1 | 0 | 10 | 1.0 | + |
| | | | (0.3) | (0) | (2.6) | (100.0) | |

[a] S = Sexual embro-sac: D = Diplosporous embryo-sac: A = Aposporous embryo -sac: ab = abnormal, malformed or aborted embryo-sac: + = Positive facultative tendency. [b] Sexuality = S/(S + D + A). Values in parenthesis are percentages (Ogburia and Adachi, 1996).

Similarly, Mr. Vice Chancellor, using the same standard protocols as outlined above, some selected African clones had shown 2.6% and 3.1% multiple aposporous embryo-sac development in *TMS 63397* and *TMS 4(2) 1425* respectively in a different study by Ogburia *et al*., 1997. Our results indicated the presence apomictic gene (s) in the genus *Manihot* which could be exploited for increased yields for mankind. Nassar *et al*., (1998) suggested a molecular and embryonic evidence of aposporous apomixis in the genus *Manihot* in Brazil, two years after our pioneering cytogenetic and histological proof of the presence of apomixis in cassava in Asian and African clones. The import of this is the validation and confirmation of our earlier works on apomixis (Ogburia and Adachi, 1996 and Ogburia *et al*., 1997) in the genus, *Manihot*.

***4.2.3 Apomixis in Plantains and Bananas (Musa sp.) -*** Mr. Vice Chancellor, sir! Plantains (*Musa* sp. AAB group) are a major source of staple food for the inhabitants of the lowland tropics of West Africa, Central America and Asian sub-regions (Karikari, 1972, Flinn and Hoyoux, 1976). Besides

being a source of staple food crop for the populace, other hidden benefits abound (Lale *et al.,* 2009) and await full exploitation for human kind. Plantains are classified according to bunch types for which there are three major types: French, False Horn and True Horn (Swennen, 1990). French plantains have many hands with numerous small fingers; True Horns have very few hands but with very large fingers; False Horns have more hands with large fingers (Swennen and Vuylsteke, 1987; Tezenas du Montcel, 1987). However, Plantain production is currently endangered by a leaf-spot fungal disease, black sigatoka (*Myscosphaerella fijiensis*), which attacks the leaves and reduces the yield by 30-50% (Stover, 1983). Breeding for apomixis could be one radical approach to surmount this sustainable production menace.

Apomixis and parthenocarpy are broadly botanically defined as embryo and seed, and fruit development respectively, in the absence of fertilization. The objectives of this study were to genetically elucidate the development of apomictic seed and parthenocarpic fruit development in the genus *Musa*. *Borneo* and *Calcutta 4* plants were vegetatively propagated and were assayed in replicates of 2 and 6, respectively at Onne and Ibadan, Nigerian locations. Each mother and ratoon was assayed over 2 flowering cycles, resulting in a total of 16 inflorescences analyzed. Pollination barrier procedures were performed involving bagging of the inflorescences, isolating them from natural pollinators. Scoring for apomixis was based on seed-set in isolated (bagged) inflorescences without pollination. Parthenocarpy was determined by seedless pulp development in open pollinated or as artificial pollination by *Calcutta 4* (a seeded wild 2n genotype), using standard *Musa* crossing procedures.





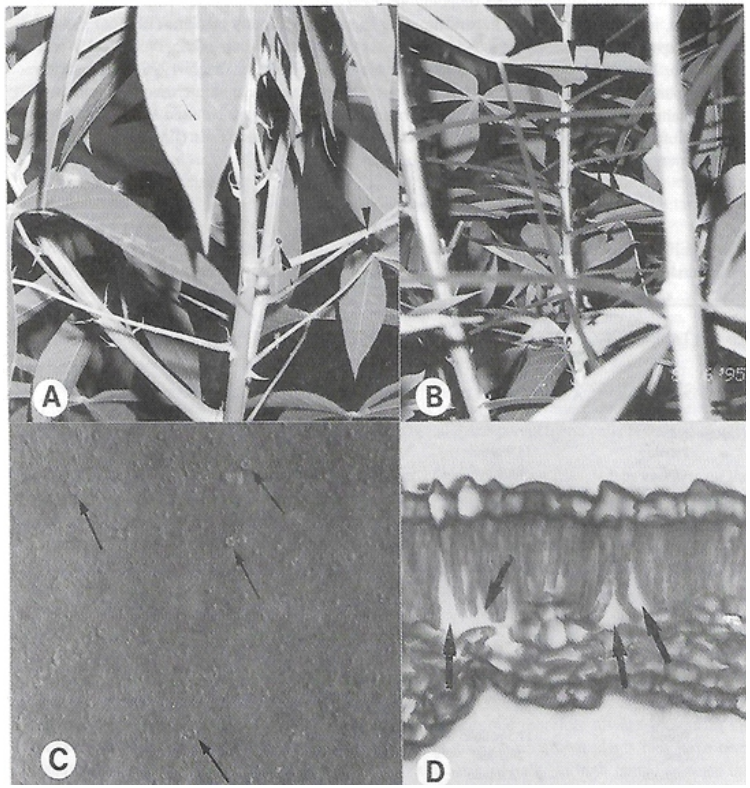


***Fig. 18. A-D - Extrafloral Nectary Systems in Cassava. A. Cassava cv, Rayong 60 showing petiolar and stipular nectar droplets, B. Cassava cv, M. Mga showing petiolar and leaf nectar droplets (arrowheads, note droplets on leaf midribs), C. Nectaries on leaf surface (arrows, note circular morphology with central depressions), D. Histological micrograph of leaf anatomy showing loose palisade parenchyma cells (arrows).***

**(Ogburia, 2004).**

It is estimated that visiting bees alone pollinate flowers at an annual cost of $2-6 billion in the US if humans were to do the pollination of flowers. However, unconsumed nectar was infected with mould which resulted in plant wilting (Fig. 19) and therefore could also impede breeding efficiency under greenhouse culture.

***Table 20: Extra-floral nectary systems in cassava under greenhouse culture conditions***

| Clone/ Organ | Average No. of Droplets | Average height of droplets (mm) | Average diameter of nectar |
|---|---|---|---|
| *Rayong 1* | | | |
| Petiole | 14.9/petiole | 2.4±0.6 | Nd |
| Leaf | 26.4/leaf | 3.0±0.9 | 2.25 |
| Stipules | 9.2/stipule | 2.5±0.5 | 0.20 |
| Stem | 16.0/stem | 1.9±0.1 | Nd |
| *Rayong 60* | | | |
| Petiole | 15.6/petiole | 2.0±0.4 | Nd |
| Leaf | 30.9/leaf | 3.5±1.0 | 2.21 |
| Stipules | 4.5/stipule | 2.1±0.3 | 0.27 |
| Stem | 16.0/stem | 2.0±0.2 | Nd |
| *OMR 3641/1* | | | |
| Petiole | 20.4/petiole | 3.0±0.7 | Nd |
| Leaf | 29.4/leaf | 3.0±0.5 | 1.25 |
| Stipules | 5.0/stipule | 2.7±0.3 | 0.30 |
| Stem | 12.3/stem | 2.5±0.1 | Nd |
| *OMR 3642/4* | | | |
| Petiole | 17.5/petiole | 2.5±0.1 | Nd |
| Leaf | 20.7/leaf | 2.5±0.2 | 0.22 |
| Stipules | 7.2/stipule | 3.0±0.5 | 1.19 |
| Stem | 15.7/stem | 3.0±0.5 | Nd |
| *M.mga* | | | |
| Petiole | 27.6/petiole | 3.0±0.4 | Nd |
| Leaf | 35.4/leaf | 3.0±.0.6 | 2.27 |
| Stipules | 5.0/stipule | 3.0±0.5 | 1.23 |
| Stem | 11.4/stem | 3.1±0.7 | Nd |

*-Mean ± Sd., Nd – Not determined (Ogburia, 2004).



Floral and fruit developmental traits indicated that *Borneo* was monoecious, comprising traits of apomixis and vegetative parthenocarpy. *Borneo* × *Calcutta 4* cross, a P1-lacking, P2 and P3 modelled *Musa*, suggests that *Borneo* may be genetically modelled to comprise P1 but lack P2 and/or P3. Such modifier genes appear to correlate with rates of genome by environment dependent seed development regimes and if not synchronized with fruit development regimes, results in dehiscence, death of developing fruit, and non-parthenocarpic expression as shown in Fig. 11 and 12. (Okoro *et al*., 2011).

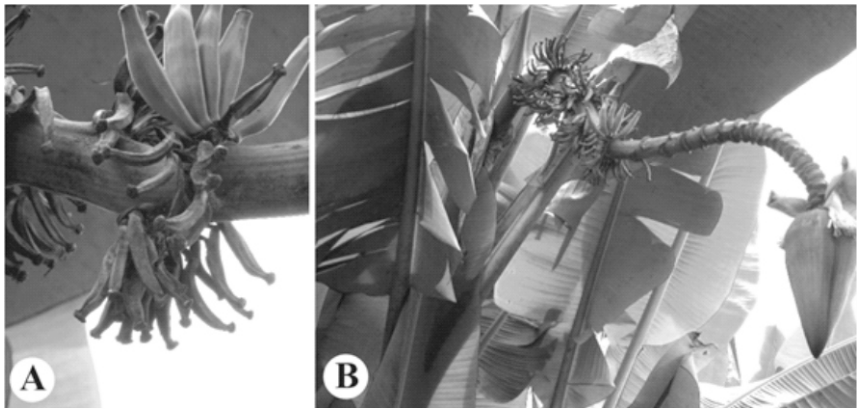


***Fig. 11. Variable Expression of Vegetative Parthenocarpy in Unpollinated Musa acuminata Subspecies Microcarpa Borneo After Pollination Barrier Bagging Assay. A illustrates a close-up view of a hand of parthenocarpic and nonparthenocarpic expression and B illustrates a typical 6 week post-emergence rachis.***

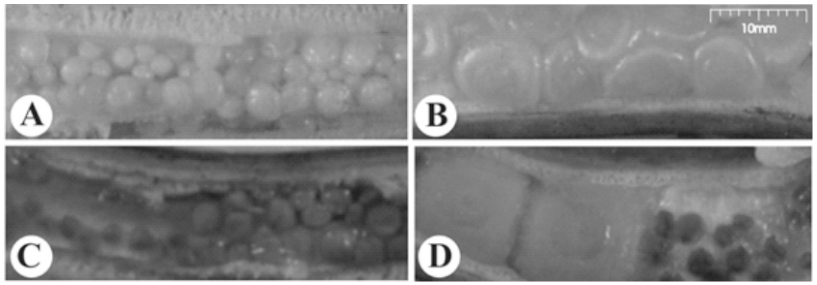


***Fig. 12. Seed and Fruit Development of Musa acuminata Subspecies Microcarpa Borneo from unpollinated hands, and a Hand Pollinated with with Musa acuminata Subspecies Burmannicoides Calcutta 4. Fruit cross sections shown are: unpollinated fingers at 13 da. (Fig. 3A) and 34 da. (Figs. 3 C and D) post-anthesis; and pollinated fingers at 13 da. post anthesis (Fig. 3 C), with pollination performed at anthesis.***

Mr. Vice Chancellor, Sir, to better understand the genome by environment (G x E) interactions that need to be accommodated in order to better predict hybrid performance for a high breeding value vegetative parthenocarpy trait *sensu stricto*. An analysis of the possible environmental signals contributing to the variability of a vegetative parthenocarpy trait *sensu stricto* via the genome x environment initiation of a genetic lesion that temporally, developmentally and systematically results in abortion of a parthenocarpic developmental regime was performed utilizing *Musa acuminata* accession Borneo as a model plant.

We examined the effect of the variable and potentially modulating environmental signals, and performed a dissection of the genetic components of expressivity and penetrance in the vegetative parthenocarpy in *Borneo*, utilizing 180 apomictic progeny planted at different developmental ages in duplicate at each of two eco-regional zones. The results of our study have produced a predictive G





about their occurrence, morphology, anatomy, ecological distribution and function in a number of plant species. EFNs have been reported in *Ipomea carnea* (Keeler and Kaul, 1979) – a tuber crop as *Manihot* and not yet in the later. EFNs have also been reported in some members of the *Euphorbiaceae*, e.g. *Ricinus* and *Croton* (Fahn, 1949).

The occurrence, distribution and function of EFNs in five (5) cassava clones – *Rayong 1*, *Rayong 60*, *OMR 3641/1*, *OMR 3642/2* and *M. mga* established in both a greenhouse and in the field were investigated visually, organoleptically, histologically and microscopically.

All the cassava clones established in the greenhouse were observed to possess functional EFNs with nectar exudates while their replicates established in the field possessed non-functional EFNs and without nectar exudates. The EFNs in greenhouse cultured plants were observed in petioles, leaves, stipules and stems (Table 20). However, number of nectar droplets varied significantly among these organs. Leaves were observed to produce the highest number (21-35) of nectar droplets per leaf while the least number (5-9) of nectar droplets were observed per stipule (Ogburia, 2004).

Morpho-structurally, EFNs on leaves were circular with discernible cavity outlined with a rim (Fig. 18). Histologically, palisade parenchyma cells were observed to be loosely organized under the EFNs (Fig. 18), suggesting that palisade parenchyma cells secreted nectar. Bees, flies, ants and wasps were observed to visit the plants for pollination of flowers which in turn enhanced hybrid seed-set.

***Table 19: Cyto-morphology and Vegetative response of cassava clones and $F_1$ Hybrids under heat stress***

| Trait | Cultivars | | Hybrids | |
|---|---|---|---|---|
| | *Rayong 1* | *Rayong 60* | *OMR 36-41* | *OMR 36-42* |
| Number of Ovaries obtained | 9 | 10 | 13 | 10 |
| Ovule Cyto-morphology | Regular | Regular | Regular | Regular |
| Plant height (m) | 1.7 ± 0.1 | 1.6 ± 0.1 | 0.5 ± 0.0 | 0.6 ± 0.1 |
| Number of branches | 3.5 ± 0.3 | 3.3 ± 0.3 | 0.6 ± 0.2 | 0.6 ± 0.1 |
| Number of nodes | 36.0 ± 5.8 | 34.0 ± 1.5 | 55.2 ± 5.7 | 51.0 ± 1.9 |
| Inter-node length (cm) | 3.9 ± 0.7 | 4.9 ± 0.2 | 0.9 ± 0.2 | 0.9 ± 0.1 |
| Number of male flowers | 14.8 ± 1.1 | 21.0 ± 1.2 | 16.4 ± 2.1 | 24.2 ± 3.1 |
| Number of female flowers | 9.0 ± 1.0 | 10.3 ± 0.8 | 13.2 ± 2.3 | 10.4 ± 1.1 |
| Time to flowering (days) | 349.3 ± 1.3 | 343.5 ± 5.4 | 293.0 ± 1.1 | 293.0 ± 0.9 |

(Ogburia *et al.,* 2000).

## 6.2 Induction of Extra-floral Nectaries (EFNs) for Pollinators in Cassava

Vice Chancellor, Sir! Pollination, the transference of pollen grains to the stigmatic surface of pistillate flowers either naturally or artificially is an important step in any conventional plant breeding process. For effective open or natural hybridization, pollinating insects are critically useful. Nectar secretion, a sign of anthesis in most flowering plants, is the most common floral reward or pay-off that plants produce to attract pollinating insects (Ogburia, 2004). Extra-floral nectaries (EFNs) are glands which secrete nectar from leaves, petioles, sepals or fruits or as in *Campsis radicans* (Elias and Gelband, 1975), from several of these structures. EFNs have been a phenomenon of recent interests to botanists, plant ecologists and plant breeders. However, despite this recent interest in EFNs, much is yet to be known



x E Model for expressivity of vegetative parthenocarpy in *Musa*, with validation of this model by a variety of statistical and probabilistic methods. Since expressivity of vegetative parthenocarpy to similar environmental signals have been identified across the monocot to dicot plants such as tomato, the generalized use of models such as presented in our study may have broader applicability to a wider range of crop plants (Shaibu *et al*., 2013).

## 4.3 Farmer First Participatory Plant Breeding in Plantains (*Musa*. sp)

Mr. Vice Chancellor Sir, Plantain breeders often focus primarily on breeding for durable host resistance to diseases and other potential pests without due cognizance to general consumer acceptability in terms of colour, taste and texture of their putative hybrids and varieties thereof, thereby *practically forcing their products (hybrids) down the throat of consumers in terms of adoption and consumption*. Farmers and consumers alike should have a choice of what to adopt in their farms and consume in their homes and that can only be achieved if they are allowed to participate in the breeding process. This is where participatory plant breeding plays a vital role for humanity as we reported hereunder.

A farmer or consumer first participatory approach was adopted to integrate farmers and consumers in the plant breeding and development research efforts to facilitate rapid and easy adoption of research findings. A field and sensory survey using a village level technique as described by Dvorack and Izac (1990) was conducted to evaluate the role of farmers and consumers in six random locations (Onne, Bori, Choba, Elele, Okehi and Omoku; 300 respondents) in Rivers State, Nigeria.

A total 259 (86.3%) of the respondents preferred the False horn bunch morpho-type and 219 (73.0%) claimed that this choice was prompted by its relative large bunch and large fingers (Ogburia *et al.*, 1999a, b). Only 12.5% and 4.0% of the respondents preferred the True horn and French bunch morpho-types respectively. The taste panelists discriminated among the plantains and derivative hybrids in all the sensory attributes evaluated. There was significant difference (LSD $\leqslant$ 0.05) in the colour of the finished products (*chips* and *dodo*). Colour was rated as very good for *Agbagba* and *Obino L'Ewai* plantain landraces representing the False horn and French bunch morpho-tyes respectively, while the colour of the products derived from *$TMP_x$ 2481* and *$TMP_x$ 548-9* were different. Similar trends were observed with taste, texture and general acceptance or preference where the landraces exhibited superior attributes (Table 6). The hybrids and *Obino L'Ewai* tasted alike but were inferior to the taste of *Agbagba*. The hybrids were inferior for most of the attributes, particularly if compared to the preferred False horn, *Agbagba*. However the in taste and ranking, the hybrids were not different from their female parents, the French bunch morpho-type *Obino L'Ewai*. Similar studies which included *Bluggoe*, a cooking banana (ABB group) were earlier conducted at IITA (Eggleston *et al.,* 1991).

This information is invaluable in planning and executing a plantain breeding programme because plant breeders need to know what the farmers and consumers need, prefer and accept (Ogburia, *et al*, 1999a), thereby encourage adoption and integration of synthesized hybrids into their farming systems. This model is similar to the numerous forms of farmer or consumer participatory research models described by Farrington and Martin (1988), including the *Farmer-*





trilocular pistil so that each pistil contained six (6) instead of usual 3 (three) ovules and lacked any outer integuments (Ogburia and Adachi, 2000). These ovules possessed functional embryo sacs with varying nuclear number. A pair of the dichotomous ovules possessed two embryo sacs of apparent different megaspore mother cells (Fig. 17). Vegetatively, $F_1$ hybrids were dwarfy (0.50m) in their phenotype and flowered 1 month earlier than the 1.50-2.0m tall cultivars (Ogburia and Adachi, 2000). Our results suggest that valuable genes could be unmasked in the genus, *Manihot* if subjected to varying environmental culture conditions. This is yet another modest but major contribution in the genetics and breeding of cassava.

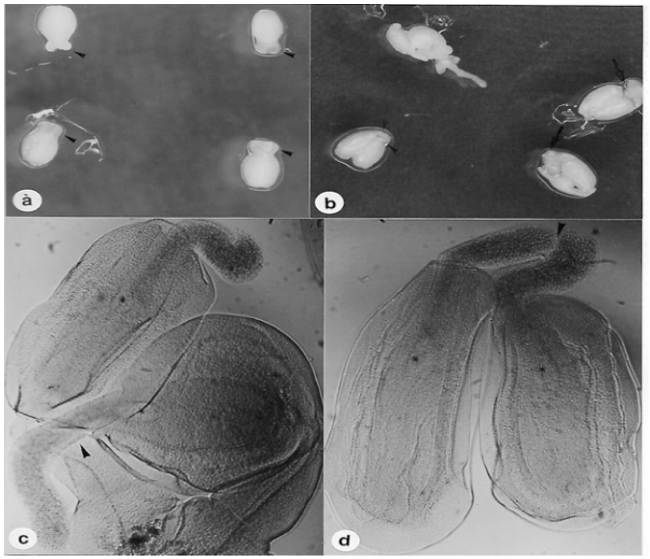


***Fig. 17. Morphotypes of normal single and double ovules of cassava, a normal single ovules after dissection from the fruit, b double ovules, c and d cleared double ovules showing normal embryo-sacs. Source: Ogburia, 1996.***

## 6.0 PHYSIOLOGY IN CASSAVA PLANT BREEDING

The Science of Plant Physiology studies how plants grow in a given environmental condition. It elucidates how plants develop from small seeds to the phenotypically huge plants, by absorbing water and nutrients from the soil and converting them into dry matter which differentiates into many useful organs for the plant itself in particular and for humanity in general (Ogburia, 2000).

### 6.1 *In-situ* Induction of Useful Genetic and Agronomic Traits in Cassava

Mr. Vice Chancellor Sir! As shown from the foregoing, efficient conventional cassava breeding is hampered by some reproductive barriers such as low fertility and low hybrid seed-set (Jenning, 1963). For example, in artificial pollination, success in crossing cultivars is 0-56% with an average of 14% (Purseglove, 1968). According to Kawano (1980), although a female flower can produce up to three seeds, it is difficult to obtain an average of 2.0 seeds per female flower. This implies that introgression and flow of exotic germplasm is significantly reduced in cassava (Ogburia and Adachi, 1995).

Therefore, any improvement in seed-set potential in this genus would be desirable. Consequently, we attempted to use heat stress as a physiological treatment to induce traits of importance in the genetic amelioration of the genus, *Manihot* and our results appear interesting.

Cytogenetic examination of the reproductive organs revealed morpho-structural features of normal pistil in all clones except *Rayong 1* which exhibited reproductive variations under greenhouse culture (Table 19). Genetically, an important variation was ovule dichotomy per locule of the



*back-to-Farmer* model (Rhoades and Booth, 1982) and *Farmer-first-and-last* model (Chambers and Ghidyal, 1985) as opposed to the conventional approach of *Transfer-of-Technology* with little or no farmer or consumer participation.

***Table 8: Sensory survey: Characterization of preferred attributes of plantain cultivars and their derivative hybrids***

| Cultivar | Colour | Taste | Texture | Acceptance | Ranking |
|---|---|---|---|---|---|
| | | *Chips* | | | |
| *Agbagba* | 2.33a | 2.08a | 2.25a | 2.16a | 1.75a |
| *Obino L'ewai* | 2.50a | 2.25a,b | 2.41a,b | 2.50a | 1.75a |
| *TMPx 2481* | 3.64b | 4.00b | 4.50b | 3.92b | 3.92b |
| *TMPx 548-9* | 3.33b | 2.83b | 2.83b | 3.08b | 2.50b |
| | | *Dodo* | | | |
| *Agbagba* | 2.16a | 1.75a | 2.58a | 1.91a | 1.16a |
| *Obino L'ewai* | 2.08a | 2.75b | 2.91b | 2.83b | 2.16b |
| *TMPx 2481* | Nd | Nd | Nd | Nd | nd |
| *TMPx 548-9* | 3.75b | 2.58b | 3.58b | 3.41c | 2.66b |

Different letters for means within a column indicate significant difference (LSD ⩽ 0.05). Scale. 1 excellent, 2 very good, 3 good, 4 fair, 5 poor, 6 very poor., nd not determined (Ogburia *et al*., 2002).

### 4.4 Breeding for Black Sigatoka Disease Resistance in Plantains (*Musa* sp.)

Vice Chancellor, Sir! The overall objective of Plant breeding is to improve those characteristics of a species that contribute to its economic value. The part of plant having economic value may be the leaf, stem, root, flower, fruit or seed. Selection can be practiced for direct improvement of the plant part or for characters that are related to reliability of

production, harvestability and marketability. The entire list of characteristics considered by Plant breeders would be too lengthy to reproduce here. Genetic resistance is the most effective means of biological control of diseases and pests in plants. Resistance of cultivars commonly eliminates or minimizes the need for chemical fungicides, nematicides or insecticides, even though the plants are exposed to pests that have the capability to injure susceptible ones. Selection for resistance to pests and diseases is an objective of most cultivar development programs. Sources of resistance from wild relatives are very important prerequisites for achieving set objectives.

Mr. Vice Chancellor Sir! A major constraint to sustainable Plantain and Banana production world-wide is black sigatoka leaf spot disease, caused by the fungus *Mycosphaerella fijiensis* Morelet. Resistance breeding is the most appropriate intervention to control this disease. Presence of epicutilar wax in leaves is one trait that may be involved in host plant resistance to the fungus. We (Ortiz *et al*., 1995) studied the inheritance of waxiness in the pseudostem, which is composed of overlapping leaf sheaths. Segregating populations were obtained by crossing triploid cultivated *Musa* and diploid improved bananas with diploid cultivated and wild bananas. Tetraploid, triploid and diploid individuals were recovered from the triploid x diploid crosses, in which one of the diploids was the wild banana *Calcutta 4* (Table 9).





***Table 17: Plant Materials' Classification and Genomic group***

| Name | Classification | Genomic Group |
|---|---|---|
| *Borneo* | *Musa acuminata* (diploid, 2n = 22, wild non Parthenocarpic banana | AAw |
| *SF 247* | *Musa acuminata* (diploid, 2n = 22, parthenocarpic cultivar | AAcv |
| *28383* | *Musa acuminata* (diploid, 2n = 22, hybrids from a cross between borneo and SF 247 | $AAF_1$ |

(Shaibu *et al.,* 2003).

Eight (8) AFLP + 3 primer pairs produced 111 polymorphic bands among the genotypes (Table 18). A higher incidence of polymorphism was revealed in the hybrids than their parental clones (Shaibu et al., 2003). Furthermore, the UPGMA analysis indicated a higher similarity among some hybrids than others. Analysis of AFLP data appears to be helpful in determining the genetic relationship among Musa genotypes.

***Table 18: Number and Size range of bands amplified in the AA Musa acuminata and their Hybrids***

| S/no | Primer Combinations | No. of fragments | Base pairs | No. of Polymorphisms |
|---|---|---|---|---|
| 1 | $E\text{-}_{AGC}/M\text{-}_{CTC}$ | 68 | 50-800 | 14 |
| 2 | $E\text{-}_{AAC}/M\text{-}_{CTG}$ | 89 | 120-600 | 19 |
| 3 | $E\text{-}_{AAC}/M\text{-}_{CTA}$ | 44 | 220-640 | 12 |
| 4 | $E\text{-}_{AGC}/M\text{-}_{CAC}$ | 101 | 160-410 | 11 |
| 5 | $E\text{-}_{AGG}/M\text{-}_{CAT}$ | 116 | 160-970 | 26 |
| 6 | $E\text{-}_{AAG}/M\text{-}_{CTA}$ | 75 | 230-650 | 9 |
| 7 | $E\text{-}_{ACT}/M\text{-}_{CAG}$ | 80 | 120-550 | 8 |
| 8 | $E\text{-}_{AGC}/M\text{-}_{CTA}$ | 68 | 50-800 | 12 |
| Total | | 641 | 50-800 | 111 |
| Average no. of bands per assay | | 80 | | |

(Shaibu *et al.,* 2003).

before declared safe for humanity. I therefore urge all of us, including our governments at all levels to accept, cultivate and consume GMO crops for food self-sufficiency and to boost our National Economy.

## 5.4 Application of Molecular Marker in Plantain Breeding

Vice Chancellor, sir, Molecular markers represent one of the most effective and successful application of molecular biology to plant genetics and breeding. For example if the magnitude of environmentally induced variation is large in comparison to genetic variation, diversity estimates based on morphological data may poorly reflect actual levels of genetic diversity among accessions.

Among DNA markers, the amplified fragment length polymorphism (AFLP) technique is widely used for genetic diversity studies because it reveals significant polymorphism and is a reliable and robust genetic diversity molecular marker assay. AFLP has been used to discriminate between accessions of a number of plants such as Soybean, Sunflower and Barley. Crouch *et al.,* (1998) suggested that AFLP technology has a high potential in contributing to the understanding of *Musa* genetics, but there has been only limited application of this technique for germplasm analysis in *Musa*.

We therefore assayed the genetic relationship between two *Musa* accessions and hybrids obtained from their crosses using molecular marker. The parent accessions as shown in Table 17 were obtained from the International Institute of Tropical Agriculture (IITA).



A

B

C

D





GMO was created in 1973; 10 years down the line, genetically modified plants (transgenics) were produced and by 1996, 2.8 million hectares of commercial crops were cultivated. By 2004, 8 million farmers in 17 countries grew 81 million hectares of modified soya beans, cotton, canola and maize (James, 2004). Genes that confer herbicide resistance and insect tolerance are the most widely used genes, commercially (MacLean *et al*., 1997, Akhurst *et al*., 2002). GMO plants or transgenic plants provide social and environmental benefits to humanity. These benefits include but not limited to (i) herbicide resistant crops need less herbicide use and tillage, which enhances organic matter content of the soil, reduces wind and water erosion (less runoff to water courses) and improves soil structure, (ii) GMO crops can produce nutrients (e.g. vitamins) lacking in some staple crops e.g. genes for vitamin A production introduced into rice (MacLean *et al*., 1997). The list of benefits can be endless but however, there are concerns as well. These include the fact that pollen grains from the GMO plants may be carried to a non-GMO crop, thus introducing the novel gene into a conventional crop and pollen grain from a herbicide resistant GMO may cross with a compatible weed and thus introduce resistance in the weed (Rieger *et al*., 1999). Many have raised concerns of GMO's health risk from being carcinogenic (cancer-causing) to social, moral and religious beliefs, but most of these concerns are not scientifically proven. It is important to state here that before GMOs or transgenic plants are released, such GMOs or transgenic plants must have passed through rigorous scientific environmental and health impact assessment. The National Biosafety Agency certifies all GMOs for safety

***Table 16: Influence of genotype and medium composition on number of embryos per meristem explant in cassava***

| Medium | SEM 1 | SEM 2 | SEM 3 | SEM 4 | SEM 5 | SEM 6 |
|---|---|---|---|---|---|---|
| *Rayong 1* | 8.3 ± 2.6b | 7.0 ± 2.2b | 6.5 ± 1.9b | 4.3 ± 2.2c | 4.0 ± 2.2b | 4.0 ± 2.2b |
| *Rayong 60* | 9.5 ± 1.0b | 5.0 ± 1.8b | 5.3 ± 3.0b | 5.8 ± 1.7c | 3.5 ± 2.4b | 5.0 ± 2.2b |
| *OMR 36-41/1* | 12.0 ± 2.9a | 10.3 ± 1.5a | 10.5 ± 1.3a | 9.8 ± 1.0b | 9.5 ± 1.7a | 6.5 ± 1.3a |
| *OMR 36-41/2* | 14.3 ± 3.3a | 19.3 ± 3.8a | 8.8 ± 3.3a | 9.3 ± 2.1b | 9.8 ± 1.7a | 8.5 ± 1.0a |
| *OMR 36-41/4* | 14.8 ± 6.0a | 14.0 ± 3.6a | 13.0 ± 2.9a | 12.5 ± 2.4a | 6.8 ± 2.1a | 8.3 ± 1.5a |
| *OMR 36-41/5* | 16.0 ± 5.4a | 17.5 ± 3.6a | 11.8 ± 3.8a | 11.5 ± 4.4a | 8.5 ± 1.0a | 6.8 ± 1.7a |

(Ogburia, 2003/4).

## 5.3 Genetically Modified Organisms (GMOs)

Vice Chancellor Sir, as a Plant Geneticist and Breeder, this lecture could be deemed deficient if no mention is made of Genetically Modified Organisms (GMOs). According to Wikipedia (2017) a genetically modified organism (GMO) is any organism whose genetic material has been altered using genetic engineering techniques (i.e., a genetically engineered organism). Plant breeders have traditionally crossed plants that exhibit desirable traits and selected among the progenies that had acquired the desired traits (Mills, 2006). With recombinant DNA technology, it is now possible to cut as small piece of DNA from a species (donor), introduce it into the DNA of another species (host) with which it could not have been crossed, in which the donor DNA is expressed. The host species, now called a genetically modified organism (GMO), thus acquires a new property it could not have obtained by conventional breeding (Nature, 2002). The first



***Fig. 13. Pollination process in Musa. A – Pollen grains from desired male parent, B – Emerging female infloresence ready for pollination, C – Artificial pollination by hand and D – Seed set in a finger. Note the only 1 premature seed (cream colour) and several aborted seeds (tiny brown colours), E – Retrieved matured (brown) seeds.***

***Table 9. Segregation for pseudo-stem waxiness in plantain-banana hybrid progenies***

| Cross | Parental Phenotype | Non-waxy (NW) | Waxy |
|---|---|---|---|
| *Calcuta 4 (C4) selfed*[1] | NW selfed | 46 | 0 |
| *SH-3362 x C4*[1,3] | W x NW | 40 | 2 |
| *SH-3362 x Long Tavoy*[1,3] | W x NW | 10 | 8 |
| *Pisang Lilin (PI) x C4* | W x NW | 31 | 15 |
| *Bluggoe x C4*[1,3] | W x NW | 14 | 51 |
| *Bluggoe x C4*[2,3] | W x NW | 0 | 1 |
| *Bobby Tannap x C4*[1,3] | W x NW | 26 | 12 |
| *Bobby Tannap x C4*[2,3] | W x NW | 0 | 5 |
| *Obino L'Ewal x C4*[1,3] | W x NW | 15 | 2 |
| *Obino L'Ewal x C4*[2,3] | W x NW | 6 | 5 |
| *Obino L'Ewal x PI*[1,3] | W x W | 2 | 1 |
| *Obino L'Ewal x PI*[2,3] | W x W | 0 | 1 |
| *French Reversion x C4*[1,3] | W x NW | 8 | 0 |
| *French Reversion x C4*[2,3] | W x NW | 1 | 0 |
| *French Reversion x C4*[1,5] | NW selfed | 29 | 6[6] |

[1]2x., [2]4x., [3]$F_1$., [4]3x., [5]$F_2$., [6]With slight pseudo-stem waxiness (Ortiz *et al.,* 1995).

*Calcutta 4* bred true for pseudo-stem waxiness. A diploid $F_1$ hybrid was the selfed to produce an $F_2$. The $F_2$ population segregated in 29 individuals with a non-waxy pseudo-stem and 6 with a waxy pseudo-stem, suggesting that pseudo-stem waxiness is due to recessive allele *wx*. Results from other crosses between *Calcutta 4* and other recessive waxy parents, however indicated that alleles with mainly additive effects are responsible for modifying the action of the dominant allele *Wx*. Moreover, a clear dosage effect, i.e., an increase in the expression of the trait in tetraploids, was obtained. The mid-parent regression values were 0.67 ($r^2$ = .48) for the diploids and 1.22 ($r^2$ = .99) for the polyploids (Ortiz *et al.*, 1995) as shown in Table 10.





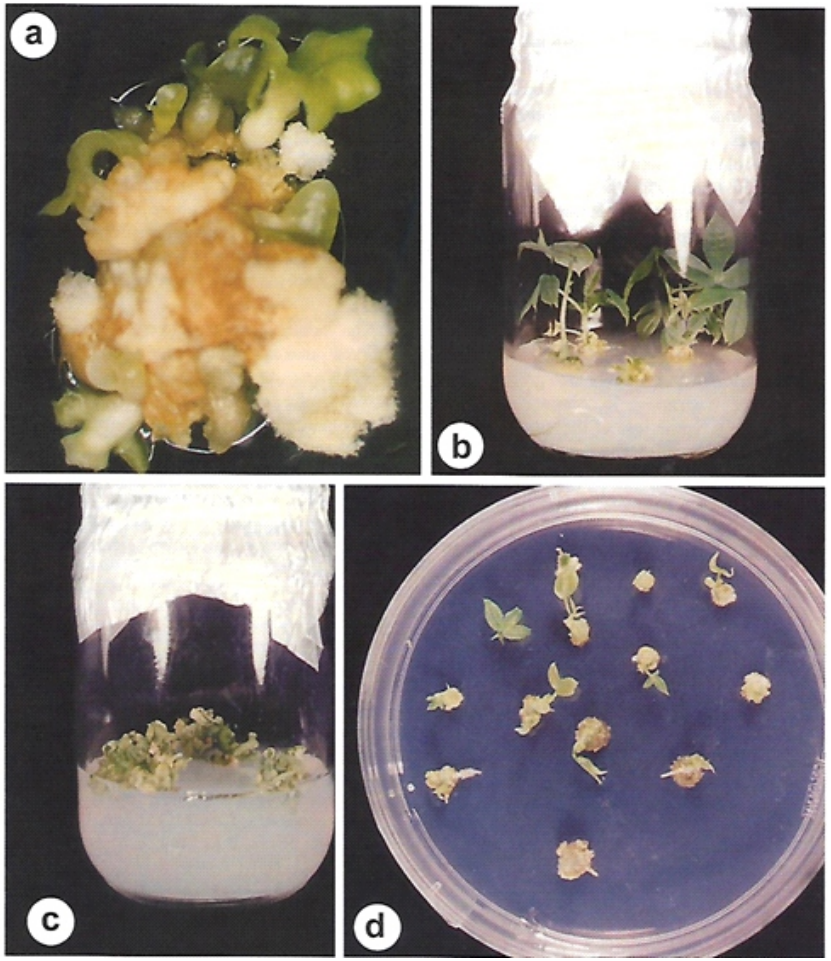


***Fig. 16. Somatic embryogenesis and plantlet regeneration in cassava. a – embryogenic callus (note globular, heart-shaped, torpedo, and cotyledonary stages), b – plantlet regeneration from somatic embryos, c – malformed somatic embryos, d – rapid nodal micro-propagation via nodal segments of regenerated seedlings (not root initials and leaves).***

(Ogburia, 2003/4).

of a number of plantlets from the few germinated seeds will be of immense value. In this experiment, we communicate the embryogenic, organogenic and micro-propagation response of explants derived from seedlings of $F_1$ hybrids in comparison with explants derived from common cultivars.

Shoot apices of the $F_1$ hybrids exhibited higher frequency (62-74%) of proliferation of somatic embryos than the cultivars (21-43%) in Murashige and Skoog basal medium supplemented with 8.0mg $dm^3$ 2, 4-D and 0.5mg $dm^3$ NAA as shown in Table 15 (Ogburia, 2003/4). Nodal explants of regenerated plantlets were rapidly micro-propagated with 90% efficiency on a medium containing 0.1mg $dm^3$ NAA and 0.05mg $dm^3$ BAP irrespective of explant source (Table 16).

**Table 15: Composition of phyto-hormones [mg $dm^{-3}$] in the induction (SEM 1 – SEM 6] and regeneration (PRM 1 – PRM 3) media. Phyto-hormones were added to MS basal medium (Murashige and Skoog, 1962) supplemented with 2% sucrose.**

| Medium | 2, 4-D | NAA | KIN | BAP |
|---|---|---|---|---|
| SEM 1 | 8.00 | 0.00 | 0.00 | 0.00 |
| SEM 2 | 8.00 | 0.50 | 0.00 | 0.00 |
| SEM 3 | 8.00 | 1.00 | 0.00 | 0.00 |
| SEM 4 | 4.00 | 2.00 | 0.50 | 0.50 |
| SEM 5 | 4.00 | 1.00 | 1.00 | 1.00 |
| SEM 6 | 4.00 | 0.05 | 0.05 | 0.05 |
| PRM 1 | 0.00 | 0.00 | 0.00 | 0.00 |
| PRM 2 | 0.00 | 0.10 | 0.00 | 0.05 |
| PRM 3 | 0.10 | 0.00 | 0.00 | 0.05 |

(Ogburia, 2003/4).



***Table 10. Degree of expression, mid-parent value, and progeny mean of pseudo-stem waxiness in plantain and banana 2x and 4x***

| Cross | Mid-parent value[5] | Pseudo-stem waxiness in Progeny[6] | | | |
|---|---|---|---|---|---|
| | | None | Slight | Moderate | Mean |
| *SH-3362 x C4*[1] | 1.000 | 40 | - | 2 | 0.095 |
| *SH-3362 x Long Tavoy*[1] | 1.000 | 10 | 6 | 2 | 0.556 |
| *Pisang Lilin (PI) x C4*[1] | 1.000 | 31 | 15 | - | 0.326 |
| *Bluggoe x C4*[1] | 1.000 | 14 | 5 | - | 0.263 |
| *Bluggoe x C4*[2] | 1.500 | - | 1 | 2 | 1.000 |
| *Bobby Tannap x C4*[1] | 1.000 | 26 | 10 | - | 0.368 |
| *Bobby Tannap x C4*[2] | 1.500 | - | 5 | - | 1.000 |
| *Obino L'Ewai x C4*[1] | 0.750 | 15 | 2 | - | 1.118 |
| *Obino L'Ewai x C4*[2] | 1.125 | 6 | 5 | - | 0.454 |
| *French Reversion x C4*[1,3] | 0.500 | 8 | - | - | 0.000 |
| *French Reversion x C4*[3,4] | 0.667 | 1 | - | - | 0.000 |

[1]2x., [2]4x., [3]$F_1$., [4]3x., [5]MPV 4 x = (3*3 x+1-2x)/4; MPV 3 x= (2*3 x+1*2x)/3., [6]Individuals classified as having slight or moderate pseudo -stem waxiness, according to their mode (Ortiz *et al*., 1995).

Phenotypic recurrent selection should, therefore, result in an increase of pseudo-stem waxiness levels for durable host-resistance to black sigatoka disease complex in *Musa*. This is yet our other major contribution to Plant Breeding Science for Humanity. Similarly, Orluchukwu and Ogburia, (2014) introgressed *bsr* gene from wild 2n accessions and derivative hybrids through hybridization to cultivated 3n landraces of Plantain. Out of 152 seeds produced from the crosses, four (4) germinated. At flowering and maturity (2years from seed to maturity) were assessed for black sigatoka resistance as described by Vuylsteke *et al*., (1993) and recovered one (1) resistant breeding line with edible parthenocarpous fruit (*USTPx/02/04*) and three (3) partially resistant hybrid with non-parthenocarpic fruit phenotypes (*USTPx/02/02*, *USTPx/02/03* and *USTPx/02/01* (Fig. 14). It is important to state here that the acronym, *USTPx* means University of

Science and Technology Plantain cross and can no longer change even though the University name has been changed to Rivers State University (RSU) by the Legislative Assembly of Rivers State in 2017. This is also the first tangible result of Plantain hybrid creation through seeds in our National Agricultural Research System (NARS) in Nigeria. These putative hybrids are currently conserved as breeding stock in our Field Genetic Conservation and Breeding plot at the Teaching and Research Farm, Rivers State University, Port-Harcourt.





***Table 14: Comparative in vitro response of cassava seedling (OMR 3641) explants under different growth regulator combinations after 21days of culture on 3 MS (1962) basal media supplemented with 2% Sucrose***

| Growth 2,4-D ($mgl^{-1}$) | Regulator BAP ($mgl^{-1}$) | Explant source | Number initiated | Callus induction (% frequency) | Weight (g) | Morphological Atrribute |
|---|---|---|---|---|---|---|
| | | Root | | | | |
| 8.00 | 0.00 | | 118 | 0 (0.00) | - | Intact & creamy white |
| 8.00 | 0.50 | | 111 | 0 (0.00) | - | Intact & creamy white |
| 8.00 | 1.00 | | 115 | 54 (46.7) | 0.5 | Compact & brownish |
| | | Hypocotyl | | | | |
| 8.00 | 0.00 | | 116 | 116 (100.0) | 1.23 | Friable & yellowish |
| 8.00 | 0.50 | | 117 | 117 (100.0) | 5.11 | Friable & yellowish |
| 8.00 | 1.00 | | 118 | 118 (100.0) | 1.42 | Compact & yellowish |
| | | Epicotyl | | | | |
| 8.00 | 0.00 | | 117 | 117 (100.0) | 0.72 | Friable & yellowish |
| 8.00 | 0.50 | | 115 | 115 (100.0) | 5.30 | Friable & yellowish |
| 8.00 | 1.00 | | 115 | 92 (80) | 1.16 | Friable & white |
| | | Petiole | | | | |
| 8.00 | 0.00 | | 120 | 90 (75.0) | 1.04 | Friable & yellowish |
| 8.00 | 0.50 | | 70 | 70 (100.0) | 4.17 | Friable & yellowish |
| 8.00 | 1.00 | | 59 | 47 (80.0) | 2.40 | Friable & yellowish |
| | | Leaf | | | | |
| 8.00 | 0.00 | | 63 | 0 (0.00) | - | Intact & greenish |
| 8.00 | 0.50 | | 77 | 33 (42.9) | 20 | Friable & yellowish |
| 8.00 | 1.00 | | 51 | 0 (0.00) | - | Friable & yellowish |
| | | Ovary | | | | |
| 8.00 | 0.00 | | 55 | 55 (100.0) | 4.00 | Friable & yellow |
| 8.00 | 0.50 | | 65 | 55 (100.0) | 4.20 | Friable & yellow |
| 8.00 | 1.00 | | 50 | 50 (100.0) | 4.12 | Friable & yellow |

a - Means of 3 replications of 10 calli each (Ogburia, 2002).

## 5.2 *In-vitro* Embryogenesis, Plantlet Regeneration and Micropropagation in Cassava

Mr. Vice Chancellor, Sir! We have all seem that the genus, *Manihot* has a lot of reproductive barriers like poor seed-set and low rates of seed germination (Ogburia, 1995) to mention but a few which impede its breeding efficiency. The application of modern tissue culture techniques to complement conventional breeding methods in regeneration

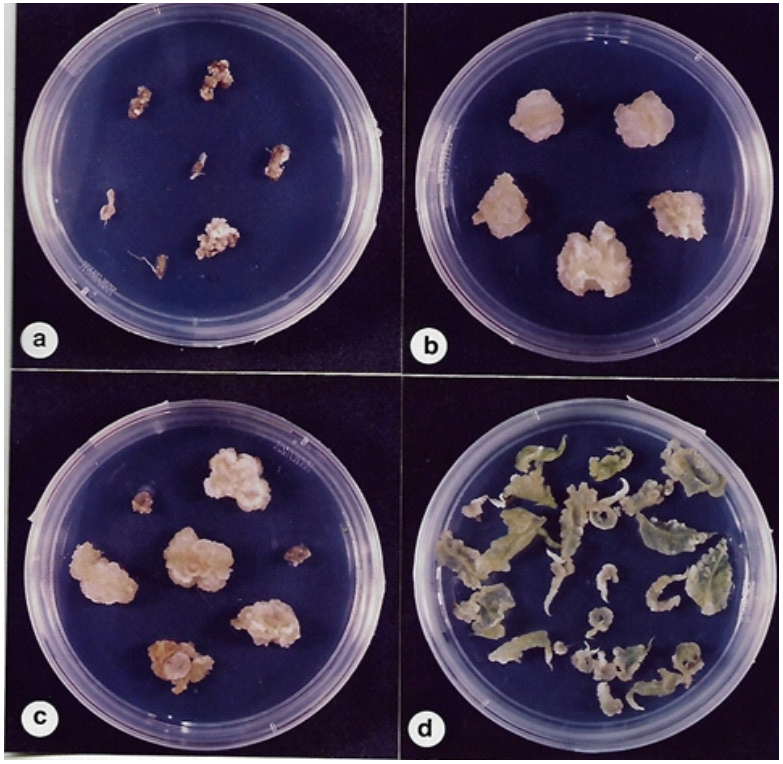


***Fig. 15. Morphogenic reaction of recalcitrant cassava explants to growth regulators (2, 4-D and BAP) in-vitro (a) roots, (b) epicotyls (c) hypocotyls and (d) leaves. Note disparities in callogenesis.***




***Fig. 14. Plantain hybrid plants and bunch morphotypes of the USTP series. Note dwarfy phenotype and parthenocarpic variance of the fingers and length of prominent rachis of different genotypes.***

Vice Chancellor, Sir! Plant size and bunch type are important morphological variables in plantain breeding programmes. The extent of organization of morphological diversity in somaclonal variants of three triploid populations (*Agbagba – True-to-Type*, *Agbagba – off – Type* and *Bise Egome – 1*) were evaluated using Principal Component Analysis (PCA).

Two principal components (PRIN 1 and PRIN 2) accounted for 36% of morphological variation in the *Agbagba – True-to – Type* (*ATT*) population, 34% in the *Agbagba – Off – Type* (*AOT*) population and 22% in the *BE - 1* population as shown in Tables 11 and 12 (Shaibu and Ogburia, 2002). PRIN 1 was loaded in inflorescence descriptors while PRIN 2 was loaded on bunch size and suckering behavior in *ATT* population. The identification of genetic variations in natural populations is

an important pre-requisite in plantain breeding programmes as in other crop breeding programmes. PCA is a reliable method for effective identification and conservation of biodiversity in the genus, *Musa*.

***Table 11: List of Quantitative and Qualitative Descriptors used for Principal Component Analysis (PCA)***

| Traits | Description Name | Description State | ATT CV (%) | AOT CV (%) | BEI CV (%) |
|---|---|---|---|---|---|
| DFL | Days to flowering | | 8.22 | 8.83 | 7.94 |
| DTH | Days to harvest | | 15.92 | 37.45 | 22.06 |
| PHT | Plant height | | 5.59 | 5.70 | 4.73 |
| GTH | Plant girth at 1 m | | 7.46 | 5.38 | 5.66 |
| YLS | Youngest leaf spotted at harvest | | 34.96 | 34.39 | 39.26 |
| NSL | Number of sucker at harvest | | 31.12 | 48.65 | 39.17 |
| HTS | Height of tallest sucker at harvest | | 46.58 | 42.61 | 37.68 |
| NSH | Number of standing leaves at harvest | | 34.95 | 36.65 | 44.18 |
| BWT | Bunch weight | | 17.12 | 44.94 | 21.58 |
| NHD | Number of hands | | 15.16 | 9.99 | 53.69 |
| FNB | Number of fingers | | 41.57 | 38.41 | 12.94 |
| NIFL | Number of intermediate flower | | 54.55 | 41.89 | 63.58 |
| BT | Bunch type | False horn = 1; French = 0 | 19.73 | 33.33 | 29.17 |
| BS | Bunch size | Small = 1; Medium = 2; Big = 3 | 41.79 | 35.80 | 35.37 |
| BO | Bunch orientation | Horizontal = 1; Sub horizontal = 2; Pendulous = 3 | 22.36 | 21.31 | 30.29 |
| FS | Fruit shape | Curve = 1; Effect = 2 | 0.00 | 0.00 | 0.00 |
| NFP | Neutral flower present | Yes = 0; No = 1 | 13.87 | 47.87 | 33.87 |
| NFPO | Neutral flower position | Sub terminal = 0; Terminal = 1; Absent = 2 | 20.78 | 9.28 | 34.97 |
| MBP | Male bud present | Yes = 0; No = 1 | 19.73 | 34.40 | 21.55 |
| MBR | Male bract | Persistence = 0; Decidous = 1 | 22.93 | 34.92 | 21.55 |
| MBA | Male bud appearance | Less prominent = 1; prominent = 2; V.prom = 3 | 13.19 | 42.76 | 25.32 |
| BAP | Bunch appearance | Lax = 0; Dense = 1 | 13.87 | 24.57 | 33.78 |

(Shaibu and Ogburia, 2002).





alternative pathway for plantlet regeneration in a breeding strategy. Three combinations of growth regulators or phyto-hormones (2, 4-D and BAP) were used for the bioassays. All plant organs were potent of callus induction but induction frequency varied significantly ($P \leqslant 0.05$). Roots and leaves were most recalcitrant to callus induction (Fig. 15). Callus fresh weight was highest (4.2-5.3gms) on 8.0mgl$^{-1}$ 2, 4-D + 0.05mgl$^{-1}$ BAP combinations for all explants (Table 10). Callus morphology varied from compact-brown to friable-yellow (Ogburia, 2002).

**Table 13: Callus induction (Percentage mean ± se) in anthers and male buds of *OMR 3642* and *OMR 3641-5* cassava clones**

| Media/Cultivar | *Rayong 1* | | *OMR 3641-5* | |
|---|---|---|---|---|
| | Anther | Male bud | Anther | Male bud |
| Hormone free MS (1962) | 0.00c | 0.00c | 0.00c | 0.00c |
| 0.10mgl$^{-1}$NAA + 0.50 mgl$^{-1}$BAP | 78.8±2.4a | 62.5±3.2a | 96.3±1.3a | 67.5±1.4b |
| 1.00 mgl$^{-1}$2, 4 - D | 61.3± 3.1b | 60.0±3.5b | 78.8±3.2b | 71.3±3.2b |

Values followed by identical letters in a column are not statistically significant at both 95 and 99% levels (ANOVA, F-test) (Ogburia, 2000).

some explants to *in-vitro* culture of some of these plant tissues is well recognized. Efforts to overcome the seeming difficulty in the *in-vitro* culture of some of these plant tissues would be desirable and our results appear interestingly informative. This investigation reports on our measured success on the embryogenic and organogenic potentials of petioles and male bud (androgenic) explants in the induction protocol of haploidy in the genus, *Manihot.*

The basal medium used was Murashige and Skoog's (Murashige and Skoog, 1962) with 2% sucrose and supplemented with different compositions of phyto-hormones as given in Table 13. Morphogenic reactions were analyzed according to Mize and Chun (1988).

Morpho-genic reactions of the explants are as shown in Tables 14 and 15. A maximum of 2 and a minimum of 1 organogenic and somatic embryos were recorded in petiole explants on an auxin (2, 4-dichlorophenoxyacatic acid) incorporated medium. The organogenic structure in petiole was in form of a shoot with two first pinnate leaf organs with discernible leaf veins (Ogburia, 2000). Petiolar somatic embryos were transluscent and heart-shaped. Male buds initially developed nodular-like embryoids and protocorm structures with the later differentiating into multiple shoots with green pinnate leaves (Ogburia, 2000).This is the first report on successful petiolar embryogenesis and organogenesis in the genus, *Manihot*.

Similarly, callus, the undifferentiated and rapidly dividing cells as important step towards somatic embryogenesis, organogenesis and plantlet regeneration *in-vitro* were executed using recalcitrant explants of cassava (roots, hypocotyls, epicotyls, petioles, leaves and ovaries) as an



***Table 12: List of Quantitative and Qualitative Descriptors used for Principal Component Analysis (PCA) Contd.***

| Descriptor | Genotype 1 (Horn) | | Genotype 2 (French) | | Genotype 1 (French) | |
|---|---|---|---|---|---|---|
| Variable | Prin1 | Prin2 | Prin1 | Prin2 | Prin1 | Prin2 |
| DFL | 0.149 | -0.46 | 0.167 | 0.387 | -0.152 | 0.464 |
| DTH | 0.864 | 0.017 | 0.092 | 0.085 | 0.019 | 0.240 |
| PHT | 0.142 | 0.025 | 0.017 | 0.138 | -0.127 | 0.083 |
| GTH | -0.114 | 0.020 | -0.093 | 0.028 | 0.005 | -0.111 |
| YLS | 0.193 | -0.348 | 0.263 | 0.086 | 0.120 | 0.291 |
| NSL | 0.217 | -0.382 | 0.289 | 0.111 | -0.262 | 0.270 |
| HTS | 0.056 | 0.303 | -0.093 | -0.263 | 0.201 | 0.355 |
| NSH | -0.063 | 0.354 | -0.0057 | -0.329 | 0.006 | 0.235 |
| BWT | -0.067 | 0.909 | -0.11 | -0.052 | 0.160 | 0.271 |
| NHD | 0.088 | -0.051 | 0.05 | 0.097 | 0.068 | 0.04 |
| FNB | -0.335 | -0.077 | 0.321 | 0.166 | -0.035 | -0.004 |
| NIFL | -0.352 | 0.102 | -0.292 | 0.212 | -0.360 | 0.171 |
| BT | 0.353 | 0.120 | 0.335 | -0.166 | 0.000 | 0.000 |
| BS | -0.063 | 0.374 | -0.095 | -0.265 | 0.159 | -0.194 |
| BO | -0.132 | 0.041 | 0.000 | 0.000 | 0.090 | 0.113 |
| FS | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| NFP | 0.038 | 0.002 | 0.051 | 0.450 | 0.261 | -0.057 |
| NFPO | 0.026 | 0.089 | 0.051 | 0.450 | 0.258 | -0.037 |
| MBP | 0.353 | 0.120 | 0.354 | -0.058 | 0.404 | 0.239 |
| MBR | 0.313 | 0.116 | 0.347 | 0.060 | 0.404 | 0.239 |
| MBA | 0.349 | 0.122 | 0.327 | -0.094 | 0.386 | 0.218 |
| BAP | -0.353 | -0.120 | -0.329 | 0.031 | -0.093 | -0.205 |
| **Eigen value** | **7.548** | **2.630** | **7.251** | **2.439** | **4.493** | **3.113** |
| **Proportion D%** | **35.944** | **12.522** | **34.528** | **11.613** | **22.466** | **15.597** |

DFL = Days to flower, DTH = Days to harvest, PHT = Plant height ; GTH Plant girth at 1 meter; YSL = youngest leaf spotted at harvest; NSL = Number of standing leaves at harvest; HTS = height of tallest sucker at harvest; NSL = Number of suckers at harvest; BWT = Bunch weight; NHD = Number of hands; FND = Number of fingers; NTFL = Number of intermediate flower; BT = Bunch type; BS = Bunch size; BO = Bunch Orientation; MBP = Male bud present; MBR = Male bract; MBA = Male bud appearance; BAP = Bunch appearance (Shaibu and Ogburia, 2002).

## 5.0 APPLICATION OF MODERN PLANT BIOTECHNOLOGY IN CASSAVA BREEDING

The term, Biotechnology is a relative new terminology in the vocabulary of scientists. The Webster's Dictionary (1976) defines biotechnology as *the aspect of technology concerned with the application of biological and engineering data to problems relating to the mutual adjustment of man and the machine.* This may seem to be solely concerned with artificial hearts, kidneys, pacemakers, artificial motorized limbs and other equipments (Frey, 1984). However, the current interpretation of biotechnology among agriculturists and the common man is much broader than this definition. Indeed, almost all research an agriculturist carries out that involves growing plants makes application of biotechnology. Generally, though biotechnology as related to plants and agriculture is interpreted to mean *the application of procedures from molecular and cellular biology to make plants more productive, more adaptive and more nutritious when produced in natural or amended environments.* This interpretation applies more to Plant Genetics and Breeding. Research proposals on Application of Biotechnology on Crop and Environmental improvements had been initiated (Ogburia, 2005, 2010). All plants, including cassava are amenable to biotechnology as a novel means of genetic improvement in the genus, *Manihot* for humankind. Plant tissue culture comprises a set of *in-vitro* techniques, methods and strategies that are part of the group of technologies called *Plant Biotechnology* (Annonymous, 2012). Tissue culture has been exploited to create genetic variability from which plants can be improved, to improve the state of health of the plants and to increase the number of desirable germplasm available to the plant breeder. Tissue culture techniques in combination with molecular techniques have been successfully used to incorporate specific traits through gene transfer. *In-vitro* techniques for the culture of protoplasts, anthers, microspores,





ovules and embryos have been used to create new genetic variation in the breeding lines, often via haploid production. The concept of plant totipotency is exemplified through biotechnology in which many somatic plant cells, including some fully differentiated types (e.g. leaf mesophyll) provided they contain intact nuclear, plastid and mitochondrial genome, have the capacity to regenerate into whole plants as shown hereunder.

### 5.1 *In-vitro* Haploid Induction via Androgenic Culture in Cassava

Mr. Vice Chancellor, Sir! The importance of Cassava in our economy need not be overemphasized. However, its cultivation is fraught with many obstacles (Cock, 1985). Reducing cyanide toxicity, raising the nutritional value, increasing resistance to pests and diseases as well as improved sustainable yields constitute excellent priorities for genetical and breeding researches. Achieving these objectives by conventional breeding is fraught with many obstacles such as high degree of heterozygosity, polyploidy, low fertility, poor seed-set and low rates of seed germination (Jennings, 1963, Martin, 1976., Byrne, 1984., Ogburia and Adachi, 1995). The application of tissue culture techniques to complement classical approaches in overcoming some of these breeding impediments will be of immense value. Successful application of this technique is largely dependent on rapid callus growth, embryogenesis, organogenesis and micro-propagation *in-vitro* of initiated explants. There are considerable reports in literature on somatic embryogenesis and organogenesis from some explants in cassava (Liu, 1975, Liu and Chen, 1977, Henshaw, 1982, 1986, 1987a, 1987b., Szabados *et al*., 1987., Stamp, 1987., Matthews *et al*., 1993., Konan, 1994, Abd Alla *et al*., 2013). The recalcitrance of