CROP GENETICS AND FOOD SECURITY

BY

PROF. MICHAEL I. UGURU

Acknowledgements

I feel very delighted and honoured to stand before you to give my inaugural lecture as a professor of Plant Genetics and Breeding in University of Nigeria, Nsukka. I will like to start this lecture by thanking the Almighty God who gave me life and the good health without which there would have been no career and of course nothing to celebrate. As a child He was with me, as a youth He did not allow me to waste and as a scholar He helped me to choose and attain the zenith of a rewarding career. To Him alone is all the Glory.

I will like to thank you specially Mr. Vice-Chancellor because my professorship was announced during your tenure. You are God sent. God recompenses every good work. He will reward you for the honest and sincere position you took with regards to the announcement of my promotion to the rank of a professor. The solid support and the wise counsel of your two Deputy Vice-Chancellors, Professors K. M. Onuoha and F. I. Idike are greatly acknowledged. Our good Lord will also reward you and your families.

I will ever remain grateful to my parents, Mr. J. O. Uguru and Mrs C.O. Uguru. You have all it takes to

be addressed as parents. I thank the Almighty God that both of you are alive to witness today's event. Your labour has not been vain. To my parents in-law, Mr. J.J. Eleonu and Mrs V.N. Eleonu , I say thank you. Your prayers have sustained me and seen me through rough times. I also thank God that both of you are alive to witness this inaugural lecture.

I am very grateful to all the members of my nuclear family. To my wife, Dr (Mrs) Joy O. Uguru, I owe an immeasurable gratitude. You are a gift from the Almighty God. Therefore you are good and perfect. My dear, I cherish the kindness, endurance and support you have given me in the past eighteen (18) years we have lived together. I want to thank my daughter, Chinazaekpere for her cool headedness and obedient spirit. These attributes have enabled me to concentrate and make meaningful progress in my chosen career. To my niece, Chinyere, I say thanks for your support and good conduct.

I would like to thank my brothers, Barrister Chuks Uguru, Mr. Godwin Uguru, Mr. Peter Uguru and Mr Paul Uguru, and my sisters, Mrs. Onyishi Awulor, Mrs Onyemalechi Chukwuemogor, Mrs. Ejime Ottah, Mrs Nwachukwu Osedunme and Mrs Obiageri Itakpe and their children for their wonderful love and for remembering my family in their prayers.

Words are not enough to express my gratitude to my PhD supervisors, Professors J. O. Uzo and I. U. Obi. The rigours you took me through during training have paid off. I will ever remain grateful to both of you. Permit me Sir, to appreciate all the members of staff and students of the Faculty of Agriculture, University of Nigeria. You have been wonderful. Your encouragements are appreciated.

My special thanks go to the Head of Department of Crop Science, Dr. K. P. Baiyeri, who read the attestation. Your prayers and words of encouragements have always been a propeller to me particularly at difficult times. To my Dean, Prof. C. A. Igwe, I say thank you. Right from September 1979, (i. e. 29 years ago) we have been together - 5 years as class mates in the B. Agric Programme and 24 years as colleagues in the Faculty. I would also like to appreciate Dr (Mrs) A. I. Achike and Dr. B.C. Echezona who were also my classmates during the B. Agric. Programme. The encouragements of Professors A. I. Ikeme, M.C. Madukwe and B.N. Mbah are highly appreciated. I am very grateful to the following christian brethren: Professors I. U. Asuzu, P. O. Osadebe, A.A. Ubachukwu and Drs. V. Ejere, E. Agomuo, E. I. Ugochukwu, A.O. Ani, and D.O.Dike. Your prayers were of immense help.

I am grateful to all my postgraduate students. We have worked as a team in the crop improvement programme. Your contributions at the different stages of my research are highly acknowledged. This gathering will continue to remind you that every effort has a reward.

To the egg heads (i.e. the older Professors in the Faculty of Agriculture I bow and doff my cap for all of you. Your decisions produced the success we are celebrating today. It is my wish that we will continue to extend the same love to the younger ones.

I also appreciate the pastor and members of Church of God Mission, Nsukka for their prayers and wise counsel. My sincere thanks also go to Pastor Emma Omenihu for his prayers for the members of my family.

In the 33rd Inaugural Lecture, Professor Nwadike wrote that he was looking forward to the Inaugural Lectures of Professors Uche Azikiwe, Queen Joy Nwoji and Michael I. Uguru. I wish to thank Professor Nwadike for the challenge. Today, I have lived up to that challenge and I also look forward to the inaugural lectures of the other two eminent professors.

I will like to appreciate all my co-tenants at the block of flats at Umunkanka where I am living. They have been wonderful neighbours in every respect.

Finally, I thank the chairman and the entire members of the senate ceremonials committee for making this day a reality.

Preamble

Today, it is my turn to share my experiences and innovations in agricultural research with the members of the University community. I arrived the University of Nigeria, Nsukka for the B. Agric. Programme on September 30, 1979 with great expectations. *Ab initio* I had an overwhelming interest to study and make a career in agriculture. I come from an agrarian community. Anybody that has travelled to Lagos from the southeast must have stopped at Umunede in Delta state. That is my town. Umunede is the food basket of Delta state. Having been brought up from that type of environment, one would not be surprised to hear that I spent about 30 years trying to obtain a good mastery of the art and science of food production. I read agriculture, wrote and still write agriculture and am a practising agriculturist. In short, the name, Uguru is synonymous with agriculture in the University of Nigeria. Some of my colleagues call me the *father of crops*. By God's grace I do not only profess agriculture, I practise it and produce crops for colleagues in the University. However, some colleagues tend to show leftist tendencies towards my approach. Well, my advice is that they change their mentality because the professor that is professing hunger like the famous economist, Malthus will not eat newspaper when hunger knocks at his door. A hungry man is an angry man but a man with hungry children is worse. A farmer may be broke financially but will never starve.

My choice of topic for this inaugural lecture was influenced by the prevalent food shortage in present day Nigeria. It is glaringly clear that food supply is on a steady decline. The consistent rise in food prices attests to this assertion. Food is the most basic human need and access to it is a basic human right. The domestication and cultivation of plants, which began almost ten thousand (10,000) years ago, were aimed at ensuring that this need was met. While food production is not a problem for the developed countries, the need to increase crop yield is an urgent issue in Nigeria and many other African countries. Today, most Africans cannot feed well. There is no pretence about this. Africa has more countries with food insecurity problems than any other region (FAO, 2004). Fakiyesi (2001) reported that about 66% of Nigeria's population live below the poverty line as portrayed by the level of food security. Even around us, some eat once, or at most, twice a day. Some eat the popular 'okpa' along with parts of the wrappings if no one is watching. With such a setting, no one may die from outright hunger, but there are high levels of nutrient deficiency diseases. The nutritional value of the food we eat is still far from satisfactory. Many organizations, including the United Nations, have defined food security in terms of ownership or access to enough food to assure healthy productive lives (World Bank). When we lack basic food intake to provide us with energy and nutrients for full productive lives, we are struggling with food insecurity. Food insecurity has been adduced to a number of factors: poverty, use of crops as biofuels, increased world oil prices, global population growth, climate change and loss of arable lands to residential and industrial buildings. No matter the cause of food insecurity, the bottom line of the matter is that there is insufficient food available. Food demand is higher than supply (CBN, 2001; Fakiyesi, 2001). If adequate food is produced, it will be available to both the poor and the rich and it will be affordable. For instance, a tuber of yam produced in Kogi State goes through three or four yam traders before it gets to the consumer in Igbo land. When the transportation cost and the profits expected by each of the yam dealers are put together, the price of the tuber becomes prohibitive to the final consumer. This type of scenario makes the Nigerian situation peculiar, and the hope for food security based on the local production system, dicey. Our agriculture is not developed and therefore may not benefit much from the current global scientific innovations. Seventy percent of the people involved in agriculture are in the age bracket of 55 – 70 years and the number of farmers has been on the decline due to age and death. There is no replacement for these ageing farmers as a large number of the youths are enlisting in commercial motorcycle transport business (okada) or abandoning Nigeria for greener pastures elsewhere. If this trend is not checked it is very likely that Nigerians will go hungry in the next ten (10) to fifteen (15) years when most of the people engaged in active farming may have become too old to work.

Mr Vice Chancellor Sir, you will agree with me that the situation is worrisome. Indifference cannot solve this type of problem. Complaining cannot either. Something has to be done and quickly too. No wonder Jawaharlal Nehru of India observed that "**most things except agriculture can wait**".

Introduction

"And out of the ground made the Lord God to grow every tree that is pleasant to the sight, and good for food" (Gen 2:9). This citation is an evidence of God's interest in the welfare of human beings. There are two areas of focus – plants that are pleasant to sight and those that are good for food. This is the beginning of genetics and plant improvement. It is therefore logical to state that plant genetics has divine origin. However, when man fell, the garden containing the divinely selected plant species was lost and the genetics and selection of desirable plants became the responsibility of man.

Throughout the ages, human beings had some vague knowledge about genetics and have tried to explain the cause of heredity. Several theories have been propounded in the past six thousand years to explain the phenomenon of inheritance. These theories include the vapour and fluid theories, preformation theories and the particulate theories. The proponents of these theories differed in their views on the subject. The validity of the theories could not be substantiated beyond reasonable doubt and the question on the mystery of how organisms could become modified or change entirely into new forms remained largely unanswered. Thus genetics has a complicated background, built up from the works of many individuals. Even with the blurred vision about heredity, human beings continued to rear plants and animals to meet man's requirements. The harvestingsowing-harvesting cycle with associated selection pressures transformed poor performing crops to desirable genotypes. Slowly and gradually, this process of expedited evolution through selection and cultivation of plants acquired the form of a routine endeavour- what we today call plant breeding.

The science of genetics emerged from the pioneer work of Gregor Mendel (1822-1884). His experimental plant was the garden pea (*Pisum sativum*). He crossbred plants that expressed contrasting characters such as flower colour, seed shape and plant height. He recognized that traits were inherited as discrete units, and that each was inherited independently. He speculated that each parent had the units in pairs but passed only one to its offspring. These units are called genes. Though they cannot be seen with the naked eyes, these genes are the things that give meaning to agriculture. They have a major role to play in determining global food security.

What is Genetics?

Genetics is the study of heredity (i.e. the function and behaviour of genes). It deals with the origin of variation, the organization of variation and how this variation is transmitted from one generation to another (Olorede *et al.,* 1982). Stanfield (1989) defines genetics as the branch of biology concerned with heredity and variation, and Uguru (2005) defines genetics as the science primarily concerned with the precise understanding of how the functional units of heritable materials (genes) operate and are passed from parents to offspring. Modern genetics involves the study of the mechanism of gene action- the way in which the genetic material (deoxyribonucleic acid or DNA) affects physiological reactions within the cell. Genetics influences many aspects of our daily lives, from the food we eat to how we identify and treat diseases. Plant geneticists produce new varieties by special treatments e.g. a hybrid variety is produced by crossing two lines that differed in several ways. Plant breeders use the techniques of budding, grafting and tissue culture to maintain desirable gene combinations originally obtained from hybridization. The use of mutagenic compounds such as colchicine, which causes chromosome doubling, has resulted in many new crop varieties.

In agriculture, crop genetic conservation, Mendelian genetics, quantitative genetics, cytogenetics, radiation genetics, molecular genetics and genetic engineering have served as useful tools for crop improvement. They are used in creating and managing variations and in recombining them into new crop varieties. The emphases have been on high crop yield, resistance to pests and diseases, adaptation to environment and specific consumer needs and the modification of plant architecture to make them amenable to harvesting, processing and industrial needs.

Conservation of genetic resources

Agro- biodiversity used in food production underpins humanity's life-support system. Agricultural intensification and expansion have destroyed biodiversity and habitats, driven wild species to extinction, accelerated the loss of environmental production services and eroded agricultural genetic resources essential for food security in the future. Genetic diversity provides the variability that enables species to adapt to changing conditions. Biodiversity is therefore basic to sustainable development and it has been recognized as a key to food security. The conservation and sustainable utilization of biodiversity were major issues at the United Nations Conference on Environmental Development (UNCED) in 1992 where it was unequivocally stated that "our planet's essential goods and services depend on the variety and variability of genes, species, populations and ecosystems." The general concern on biodiversity conservation finally found expression in the Convention on Biodiversity to which Nigeria and over 160 other countries are signatories. The Convention proposed that biodiversity be conserved. The three articles of the convention are: conservation of genetic resources, sustainable utilization of the resources and access to and transfer of technology. Genetic diversity adds insurance to our food system, protecting our food crops against diseases and natural disasters. Unfortunately, many of our native food crops have already disappeared or are disappearing for lack of adequate care and conservation. In terms of wild harvests, villagers in Nigeria eat wild leafy vegetables like *Ukazi - Gnetum Africana,* U*ha -, Pterocarpus spp*., *Utazi - Gongronema latifolia* and tree crops like African star apple - *Crysophylium albidium*, bitter kola - *Garcinia kola*, Oil bean tree - *Pentaclethra macrophyllum*, African breadfruit - *Treculia africana*, African nutmeg - *Myristica fragrans* etc. Sadly, many of the sources of our nutritious food plants are now endangered. Many of the traditional varieties of cocoyam, banana, sugar cane and wild yams are terribly threatened, as are fruit and medicinal trees. More worrisome still, is that the current generation does not know the names of these native plant species. They cannot identify the plants and therefore are not in the position to protect or plant them. As part of the price for modern-day life, no one has time to prepare meals from these indigenous herbs; junk food is the norm for both rural and urban dwellers and no one is spared its effects.

Despite the legislation against bush burning in Nigeria, thousands of hectares of forests and grasslands are burnt annually, resulting in the loss of valuable genetic stocks. There is therefore the need to create sufficient awareness among the populace on the importance of indigenous plant germplasm. Thus the basic principle of genetic conservation should be taught at the secondary and tertiary institutions. This can be incorporated as a study topic in Biology in the secondary school and in Natural Science in the General

Studies curriculum in the University. The government should appreciate the value of the native plant species. It must put the machinery in place to harness and utilize the knowledge of the rural communities (Uguru, 1998). Identifying the indigenous knowledge and modernizing it for development should be a priority and a mission for people seeking to lift themselves out of poverty.

Mendelian|Qualitative genetics

The early part of my research in genetics took after the steps of Gregor Mendel. The difference however, was in the experimental plant. Whereas Mendel worked on the garden pea, my experimental plant was the vegetable cowpea (*Vigna unguiculata* (L.) Walp). There were three reasons for selecting the vegetable cowpea for genetic studies and improvements. The first reason was its protein contribution in the local diet. The second was its earliness in podding thereby supplying food during the 'hungry season' and the third was the indeterminate podding pattern that ensured continuous supply of food to the household over a range of time. Most cowpea producing areas in Nigeria are located in the drier savannah ecologies of the north whereas much of the grains produced are consumed in the region south of 10^0N latitude where precipitation exceeds potential evapotranspiration. Therefore, development of cultivars that are adapted to the wetter regions will significantly increase cowpea production thereby addressing the dietary protein need of the rural and urban poor in the south. On this premise, I embarked on the improvement of the vegetable cowpea through the conventional hybridization methods. I achieved hybridization between the vegetable and grain cowpeas in 1989. By 1991 the genetic basis for the inheritance of the three growth habits (Uguru, 1994) in vegetable and grain cowpeas was reported (Uguru and Uzo, 1991a). The genetic ratio obtained implicated a modifier gene interaction in which the genotype *A-B-* has the decumbent growth habit; the genotype *aaB-* had the climbing and *aabb* had the bushy habit. A similar work on cowpea, as at then, was not in the literature and the research was therefore considered novel and published as a pioneer investigation on growth habits of cowpea.

Another aspect of qualitative genetics on vegetable cowpea was on the genetics and association studies on pod shape. Detailed analysis of the F_1 and F_2 ratios implicated perfect dominance of coiled and curved pods over the straight pods. The study of pod shapes dates back to the Mendelian work on garden pea, where a 3:1 monohybrid ratio was reported. Further re-examination of the report showed that the inheritance of the trait was governed by either of the two genes, *P*. and *V* (Blixt *et al.,1*978). While Nilson (1951) implicated the former locus, Lamprecht (1968) believed that it was the *V* locus. Contrary to these views, pod shape in the vegetable cowpea was reported to be under the control of the two loci *PP* and *VV* (Uguru, 1995a).

Vegetable cowpea pods are eaten whole in the fresh state as a vegetable and the pigmented types impart attractive colour to the dish after boiling (Uguru 1996a). Colour plays an important role in our enjoyment of foodstuff. It is appreciated both for its aesthetic role and as a basis for assessment of quality. In the latter, colour gives visual cues to flavour identification and taste thresholds, influencing food preference, food acceptability and ultimately food choice (Bridle and Timberlake 1997). Existing evidence indicates that anthocyanins are not only non-toxic and non-mutagenic but has positive therapeutic properties (Saija, 1994) for the treatment of various circulatory disorders (Bettini *et al*., 1985) and inflammatory diseases (Vincieri *et al*., 1992). In spite of all these health promoting properties, people particularly the elite despise anthocyanin rich vegetable cowpea for baked beans and the grain cowpea. Inheritance studies on pigmentation in grain cowpea have been carried out (Kolhe, 1970; Phadnis, 1976). My research on the inheritance of the contrasting petal, pod and shoot colours revealed that pod colour is governed by one allelic pair, *WW* while the pod and shoot colours were determined pleiotropically by two allelic pairs, *Pr Pr* and *Gr Gr*, interacting in the form of a recessive suppressor (Uguru 1995b). Several loci have been implicated in the inheritance of colour patterns in vegetable cowpea

(Uguru, 1995b; Ngwuta and Uguru, 2000; Leopold and Kriedemann, 1975). The question that arose from this report was how the loci were distributed in the genome. In the quest for solution to this question, I initiated a research with a postgraduate student on the linkage relationships of anthocyanin genes with a view to determining the joint segregation pattern of the calyx, petal and pod colours. The result indicated that all the known markers for colour are arranged in one linkage group. The petal and calyx colours were the most tightly bound with an estimated distance of 0.0567 ± 0.009 genetic map units (Uguru and Ngwuta, 1995).

Quantitative genetics

Unlike qualitative characters that are classified into discrete phenotypic categories, the variability observed in quantitative traits form a spectrum of phenotypes from one parental extreme to the other. Heritable traits such as grain yield, fruit size, pod length and pod weight are quantitative characters. Offspring show continuous variation with respect to these characters because the gradation from one individual to the next is not perceptible except by weighing or measurements. Because of the difficulty of measuring individual additive effects, the genes are usually estimated *en bloc* using statistical procedures to reach genetic deductions. The choice of efficient breeding procedure for the genetic improvement of a population is contingent upon the knowledge of the relative magnitude of the components of hereditary variance - additive, dominance and epistatic - for the trait in which improvement is sought. Instances of additive and dominance gene effects as the major components of gene effects have extensively been studied (Lal *et al.*, 1975; Chatrath, 1986). In all the yield attributes measured in the hybridized vegetable and grain cowpeas, the estimates of the additive gene effects were rather low in magnitude, suggesting minimal contribution of additive gene effects (Uguru and Uzo, 1991b). This report was not in agreement with Robinson *et al.* (1955) and the disagreement was attributed to the failure of the authors to recognize the contributions of the epistatic gene effects which introduced some bias to the estimate of the genetic variance. The improvement strategies recommended for achieving high grain yield in hybridized vegetable and grain cowpea were the use of reciprocal recurrent selection and the use of hybrid programmes (Uguru and Uzo, 1991b).

For a character to develop and manifest, the gene or genes controlling the character must be present and the proper environment for the character to develop must also be available. Thus, both heredity and environment are important in determining the expression of characters. Every crop geneticist is interested in knowing the magnitude of the observed variation of the phenotype in a population that can be attributed to genetic causes and environmental variations. The geneticist must be able to distinguish the genetic from the non-genetic components of variation before determining the mode of inheritance of a metric trait. This is usually achieved by estimating heritability which is defined as the percentage ratio of the genetic variance to the total variance (Allard, 1960). Heritability and its usage in both broad and narrow sense are well documented (Poehlman 1987; Uguru, 1995c). The heritability in a narrow sense often defined as the ratio of the additive genetic variance to the total variance is of primary interest to the crop breeder. Using the data obtained from the parents, F_1, F_2 and backcross populations heritability in a narrow sense for yield and yield components in hybridized vegetable and grain cowpeas were obtained (Uguru 1995c).

The phenomenon of heterosis has generally been studied in relation to some arbitrarily selected traits such as size, weight or yield. Heterosis is then regarded as being manifested by an increase in the chosen trait. Although various definitions have been proposed (Quinby, 1970; Walton, 1971), heterosis is most commonly and most meaningfully defined as an increase in a chosen trait in crossbred individuals as compared to the better inbred parent. In an effort to address the problems of planting materials, my crop improvement work with my postgraduate research students were extended to two other important vegetables - tomato (*Lycopersicon esculentum*) and fluted pumpkin (*Telfairia occidentalis)* and one field crop, castor (*Ricinus communis*). The objectives were to investigate the expression of hybrid vigour and possible exploitation of F_1 plants to an advantage for the poor resource farmers. Our findings provided strong evidence of exploitable heterosis in crosses involving distantly related lines in castor (Uguru and Abuka, 1998) and in tomato (Uguru and Umukoro, 2005). The unavailability of planting materials for these two crops underscores the importance of these investigations. Most of the tomato seeds used in Nigeria are imported and the performance in the south is usually poor because of high precipitation. Selection of castor seeds is based on the farmers' discretion in that seeds of impressive castor plants are simply kept for the next season's planting. Several local cultivars, varying greatly in both growth and yield characters have arisen from this selection process. Their yields are unstable with serious implications on returns to investment.

Cytogenetics

The nucleus of the plant cell contains a complete blue print for every plant. The information resides on the chromosomes made primarily of long chains of Deoxyribonucleic acid (DNA), the master chemical that controls the development and functioning of organisms. The crucial components of the DNA are four nitrogenous bases - adenine (A), thymine (I), cytosine (C), and guanine (G). The sequence of these bases determines the order in which amino acids are linked together to form proteins. Each complete DNA 'sentence' is a gene, a discrete segment of the DNA string responsible for ordering the production of a specific protein.

A good knowledge of the cytogenetics of some important commercially cultivated crops is useful in our crop improvement endeavours. It is helpful in understanding heredity in crops with clear cut sexual dimorphism such as the fluted pumpkin and those with barriers to successful hybridization such as bambara groundnut and pepper. Meaningful agricultural research must be consumer focused, market driven and farmer focused. It is important that it aims at solving a specific local problem. For instance, our research on fluted pumpkin was set out to assist farmers identify male plants and possibly replace them early enough with the preferred female plants that attract higher premium.

Mr Vice-Chancellor Sir, the age-long problem of early identification of male fluted pumpkin with a view to replacing them with the more succulent females for higher premium has been solved in the course of our crop improvement programme. Sex linked morphological markers consisting of early and profuse production of tendrils as well as the relatively slow growth rate of the male plants can easily be identified by all fluted pumpkin growers. With this it is possible to reduce the population of the male plants in the farmers' field to the barest minimum. At the chromosomal level, my PhD student and I were able to establish a strong evidence of identical sex chromosomes in the female plant and non-identical sex chromosomes (Plates 1 & 2) in the male plant thereby establishing the XY system of sex chromosomes in fluted pumpkin. The chromosome pair number 5 showed this discernable difference. The research provided the basis for the sexual dimorphism in fluted pumpkin with heterogametic XY male and homogametic XX female.

Mr Vice-Chancellor Sir, it is important to let you know that this finding is novel and the paper is under consideration for publication in one of the highest journals in the world – Science.

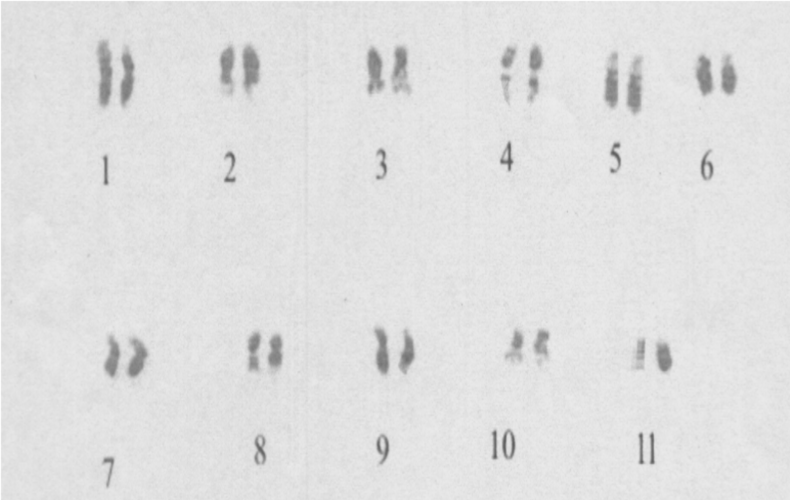


Plate 1: Karyotype, showing identical pair of Chromosomes No. 5 in the female plant

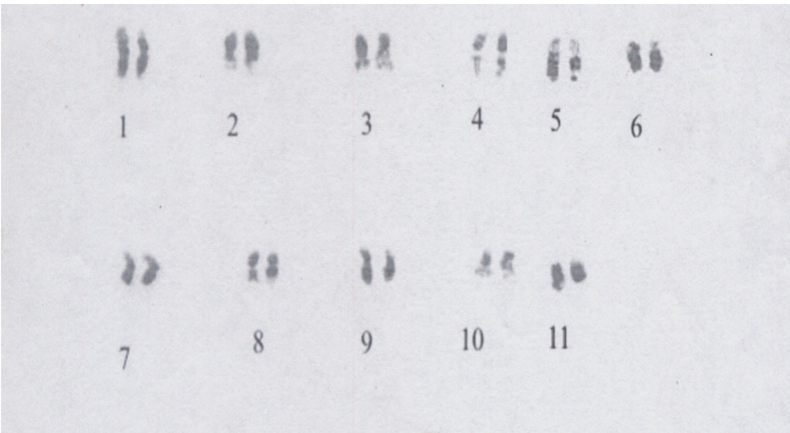
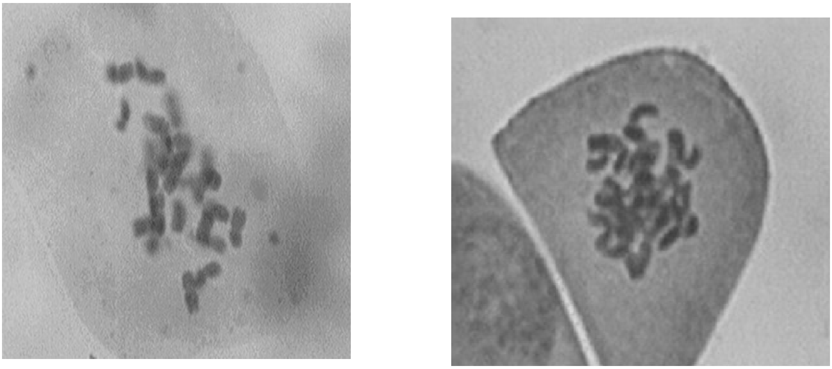


Plate 2: Karyotype, showing non-identical pair of Chromosomes No. 5 in the male plant

Bambara groundnut did not show much difference in its karyotype to provide satisfactory explanation for the extreme difficulty in achieving sexual hybridization between the existing genotypes (Uguru and Agwatu, 2005). The failure to achieve successful hybridization has been traced to the very short life span of the pollen grains after detachment from the anthers. Because of the unique qualities of bambara groundnut in the local diet our research was extended to establish some agronomic requirements for optimum yield in southeastern Nigeria. The effects of five different soil types – alfisol, entisol, inceptisol, ultisol and vertisol on growth, nodulation and yield of bambara groundnut were investigated and only three of the soil types, vertisol, alfisol and ultisol showed some promise for successful cultivation of bambara groundnut (Uguru and Ezeh, 1997)

We made some attempts to produce new lines from crosses between *Tatashe* and Nsukka yellow pepper with very minimal success. The initial plan was to transfer the aroma in Nsukka yellow into the resulting progenies. However, it was very difficult to achieve successful hybridization. There was no discernable difference at the chromosomal level (Plate 3) to explain the failure in many of the hybridization attempts made. They have the same number of chromosomes and identical karyotypes. Further enquires implicated chromosome abnormalities in the pollen mother cell. However, Nwankiti (1981) implicated morphological problems related to the forms of male and female floral parts.



A B

Plate 3: Mitotic Chromosomes of (A) *Tatashe* and (B) Nsukka Yellow Pepper

Additional investigations on the Nsukka yellow pepper revealed that the crop grows successfully and produces its characteristic aroma when planted in locations outside Nsukka (Uguru, 1999; Uguru, 2000) contrary to the common belief that the Nsukka yellow pepper loses its aroma if it is planted in regions far away from Nsukka. Pepper is generally susceptible to many disease causing organisms. Viral and bacterial diseases are the most devastating. In an attempt to establish the genetic basis for susceptibility or tolerance to the common disease pathogens of pepper we applied the concept of Principal Component Analysis. Genetically related genotypes tend to cluster, indicating that there is a significant genetic component to the underlying patterns of variations in growth and disease attributes (Uguru and Madu, 2006).

Our cytogenetic works on tomatoes, African yambean and pumpkin revealed chromosome numbers of 2n = 24, 2n = 18 and 2n = 22, respectively. There were no disturbing differences between the chromosomes of the wild tomato relative, *Lycopersicon pimpenillifolium* and the cultivated tomato *L. esculentim* (Uguru and Atugwu, 2006). Thus, the interspecific hybridization between both species was achieved without much difficulty.

'Hope' variety (AWARD WINNING VARIETY)

This is the major landmark made in my crop improvement research. It is the product of the interspecific cross between a wild tomato relative and a commercially cultivated tomato. The wild tomato relative is a high humidity tolerant line capable of producing up to 743 tiny fruits per plant and it is a major source of disease resistant genes (Foolad and Lin, 1999; Tanksley *et al.,* 1996), Crosses between the commercially acceptable but poorly adapted cultivated variety and the wild tomato variety produced genotypes that segregated in many loci of commercial importance including pest and disease resistance. Successive evaluation of the progenies at different filial generations showed reliable evidence of genotypes with potentials for disease resistance (Uguru and Igili, 2002; Udo *et al*., 2005), increased fruit size (Uguru and Onwubiko, 2002) and increased fresh fruit yield (Uguru and Umukoro, 2005). At the 12th filial generation (1997-2007) the final selection – 'Hope variety' was made. This scientific breakthrough won the 1st prize in Science in the 3rd All Nigerian Universities Research and Development Fair (NURESDEF) held at the AKOKA campus of University of Lagos from 23rd to 27th March 2008.

Wild

tomato relative **Cultivated tomato**

Hope Variety

Mr. Vice-Chancellor Sir, this award winning tomato variety is endowed with the following attributes:

- Good adaptation to high rainfall conditions

- High lycopene content with prophylactic remedy for prostate cancer
- Resistance to high humidity diseases
- Prolonged shelf life of the fruits
- High beta-carotene
- Low water content

Another Novel Crop variety obtained through selection in my crop improvement programme is the **Jumbo Banana. It is** specially selected for commercial banana growers.

Mr Vice-Chancellor Sir, it is interesting to inform this great audience that many of our colleagues have collected this novel banana genotype. Reports from those growing the banana are heart warming and encouraging. With good management, jumbo banana produces an average bunch weight of 42.5 kg. Each hand contains about 19 fingers and weighs about 5kg. Each finger weighs on the average, 263g. The extra-ordinarily large fingers and the attractive yellow colour of the mature ripe fruits constitute the selling qualities of jumbo banana.

Jumbo banana

Miram is another novel crop variety I developed in my crop improvement programme. Pawpaw is food, drink and medicine. The recent realization of these three functions of pawpaw made the demand to exceed the supply. Miram was developed to satisfy a family of ten either as fruit drink or as a dessert after a meal. However, the research on Miram is not concluded yet because of its high susceptibility to the ring spot virus. The improvement of Miram will continue until a tolerant variety is developed.

Miram **Normal commercial**
The novel variety **Pawpaw fruit**

Radiation Genetics

Mutation induction is an established tool in crop improvement to supplement existing germplasm and to improve cultivars in certain specific traits. Hundreds of improved varieties have been obtained through this process and released to farmers thereby demonstrating the economic value of the technology. The first observations about artificial induction of genetic changes date back to the beginning of the 20th century (Gagar, 1908) but proper proof of Mendelian inheritance of such induced changes came only in the late twenties with the use of X-rays as mutagens (Muller, 1927; Stadler, 1928). Friesleben and Lein (1942) developed mildew resistant barley and a practical mutation breeding procedure. The dawn of the Atomic Age, following World War II saw a boom of interest in utilizing ionizing radiation for peaceful purposes. By 1950, mutation induction research became very popular and began to flourish in many countries in the west. In the beginning, mutation induction was based primarily on X- rays, but later gamma rays, and to a small extent fast or thermal neutrons were introduced. Chemical mutagens are also effective but their wide variety made it difficult to establish common rules for safe use, although the need for these was recognized (IAEA, 1977). Improvement by radiation is not restricted to seed- propagated crops alone. Pollen irradiation has been carried out, but a controversy in terms of its superiority or inferiority over seed irradiation is yet to be resolved. For vegetatively propagated plants, bud irradiation using cuttings, grafts, tubers, bulbs etc has always been a choice method.

The use of induced mutation in crop improvement is profitable (Sato, 1982). From 1962 to 1984, more than 600 mutant varieties were produced, approved and released for cultivation (Micke and Donini 1982; Gottschalk and Wolf, 1983)

Molecular genetics

Conventionally, plant breeders use visual traits to identify plants carrying a gene of interest in a population. In instances where recessive and polygenic traits are involved, it is necessary to raise a large population. Result-targeted screening is usually difficult particularly where there is genotype X environment interaction. With the discovery of DNA-based markers such as Random fragment length polymorphism (RFLP), Random amplified polymorphic DNA (RAPD), Amplified fragment length polymorphism (AFLP), simple sequence repeat (SSR), micro and mint-satellites, it is now possible for breeders to identify the precise location of the gene of interest. The target genes can be identified in a segregating population based on genotype as determined by patterns of tightly linked molecular markers rather than on phenotypic expressions. This technique is called the Marker–Assisted Selection (MAS). Its application is rapid and it has accelerated different breeding programmes making it possible to reach the breeding objectives within specified time. The technique has been used for rapid introgression or backcross breeding of simple characters. It has enhanced knowledge of breeding materials and systems, e.g. better understanding of Quantitative Trait Loci (QTL). DNA markers have also been used for early or easy indirect character selection.

Genetic Engineering and Production of Genetically Modified Organisms (GMOs)

This technology makes it possible to locate genes for certain traits, cut them from one organism, and put them into another even if the target organism is of a different species. Because all genes are composed of the same material, they can be transferred between many living things. This technology that allows plant breeders to transfer genetic traits among sexually incompatible organisms, such as entirely different plant species, bacteria or even animals is referred to as **Genetic Engineering**. The technology concentrates on specific genes in the plant rather than working with the whole plant. It is a faster means of transferring specific characteristics than the traditional methods of crop improvement. **Transgenic crops** with herbicide, virus or insect resistance and delayed ripening have been produced with this technology.

Genetically Modified Organisms (GMOs)

GM (Genetically Modified) is a special set of technology that alters the genetic make up of living organisms. Combining genes from different organisms is known as **recombinant DNA** technology, and the resulting organism is said to be genetically modified, genetically engineered or transgenic. Put in a simpler language, a genetically modified organism is any living organism that possesses a novel combination of genetic material through the use of modern biotechnology. This technology is new and like all new technologies, it has both known and unknown risks. The controversies surrounding GM foods and crops have centred on human and environmental safety, labelling and consumer choice, intellectual property rights, ethics, food security, poverty reduction and environmental safety. Encouragingly, GM technology has some benefits. In crops the GM technology enhances tastes and quality, early maturity, increased nutrients, yield and stress tolerance, improved resistance to pests, diseases and herbicides, and improved post-harvest storage. There is no doubt that biotechnology has made a rapid entry into the agriculture of Argentina, Brazil, Canada, China, South Africa and the United States of America. These countries have organized agricultural systems with discernable government interest in form of subsidy and research. In contrast Nigerian agriculture is not developed and greater proportion of agricultural production is in the hands of the peasant farmers (Uguru, 2008). Therefore leaping into biotechnology and the use of genetically modified crops will bring with it a wide range of biosafety issues including health and environmental risks, as well as broader socio-economic impacts. In the first instance, Nigeria cannot produce GM or transgenic crops for the following three reasons: (1) Nigeria does not have the competence and resources to produce them (2) the production of GM crops is presently in the hands of multi-national corporations in the West whose interest is profit maximization. No organization will compromise her business strategy and channel of profit no matter how magnanimous. (3) The producers of transgenic crops do patent all the transgenic seeds that they produce. For them, it is a commercial business like any other which requires a guarantee of a return on their investment. These facts make it glaringly clear that the producers of seeds of GM crops will enjoy the monopoly of production and supply - at least in the foreseeable future. Nigeria will only be an importer of these alien seeds. Therefore, to expect maximum benefits as an importer of finished products is synonymous to the proverbial ownership of a cock by a child. GM technology is a high input technology and the cost of the products could be prohibitive. Majority of the Nigerian farmers cannot afford them. The herbicide-tolerant varieties will boost yield and reduce cost of production at the short run. The long term effects may not be as beneficial. The likelihood of dumping herbicides on Nigerian market arising from increased demand to actualize the gains of using herbicide tolerant species cannot be ruled out. At present, there is no information on the fate of GM seeds following continuous use. Will GM plants breed true or will the traits of interest disappear in the course of time following gene recombination? The introduction of Terminator gene (gene incorporated in a seed so that it cannot be re-sown) in GM plants is a clear manifestation of the exploitative dimension of the GM technology (Uguru, 2006). Peasant farmers in Nigeria depend on seeds saved from previous plantings for continuity. GM seeds will only fit into the traditional farming systems if they can germinate and breed true from year to year (Uguru, 2003). Fresh procurement of seeds on yearly basis is not part of the traditional farming system. Fresh supply of seeds on yearly basis would have serious financial implications on the poor resource farmers, indigenous technology and on the government. Farmers who cannot afford the extra cost of procuring seeds on yearly basis may decide to abandon the GM seeds for the original seeds they are used to. Of course, this may not be realizable if the original landraces and local varieties have been lost due to abandonment or contamination as a result of pollen drift from the GM crops.

The science of transgenic creations has also left some doubt on the minds of many. The methods of inserting the alien genes into the host plant could be imprecise. Most of the DNA sequences may be inserted in the wrong place and in the wrong order, the consequence of which is the interruption of important DNA sequences that already exist in the organism. For example, the transgenic papaya developed and grown in Hawaii was modified to be resistant to the ring spot virus. After a few years of planting, it was observed that the papaya was a weak tree and more susceptible to the black spot fungus. The lesson to be learnt here is that no gene works in isolation but rather as part of an extremely complex genetic network.

In order to develop our food security, we should not be turning towards America or Europe but should be looking inwards to harness and maximize (the utilization of) our God given resources. We are easily carried away by new technologies from the west. This has had some damaging effects with very severe consequences on the development of our country. May I remind Nigerians that both the government and the people have nothing in place to shield the country from the impact of unforeseen dangers that may arise from the prolonged use of GM crops. The advanced economies have put the necessary outfit in place to assess, monitor and perhaps authorize the sale and use of GM crops. The roles of the German Office of Consumer Protection and Food Safety (BVL), EU Environment commissioner, Stavros Dimas and the European Food Standards Authority (EFSA) are just a few of such outfits. In Nigeria, such outfits are heard about more in media houses and read on the pages of Newspapers. They hardly make any meaningful contribution in the society. Nigerians cannot deny that many of our native landraces and crop species are disappearing due to incessant bush fires, climate change and urbanization. No visible attempt is being made to check this painful trend. The introduction of GM seeds will be the last straw that will break the camel's back. Pollen drift and the eventual degeneration and loss of our biodiversity will make us perpetual slaves until the trend is reversed. I am of the opinion that it is still too premature to introduce GM crops into the Nigerian Agriculture as the wealth and knowledge of Nigerian farmers in the indigenous farming culture is immense. In Nigeria, more than two thousand native grains, roots, fruits and other horticultural crops are found. These have been feeding people for years but unfortunately most of them are receiving no scientific attention today.

Modern biotechnology, if appropriately developed, could offer new and broad potentials for contributing to food security. Nigeria should approach the GM technology from a beneficial viewpoint. The starting point will be human capacity building - a critical mass of people with abilities to evaluate and manage technology. A strong and knowledgeable scientific community will help select the GM technology application that will be most beneficial for Nigeria. Not all the applications are beneficial or equally understood. It is critical that Nigeria carefully picks the type that will satisfy her needs and benefit her citizens. These facts must be borne in mind:

- Nigeria must harness the remarkable forces of science and technology that are remoulding our world

- Nigeria must make this age of science and technology a true age of possibility for all Nigerians.
- The government of Nigeria must invest in science and technology by promoting research.
- Encourage collaborations between Nigerian institutions and institutions in the west.
- Introduction of GM crops should, at present, be at the bioplot level.
- Introduction of GM crops for distribution to farmers for planting may be considered when:

(i) Sufficient proofs concerning the biosafety of GMOs are available

(ii) Sufficient machinery for the protection of our indigenous germplasm units are in place.

(iii) Sufficient training of users of GM crops or extension agents has been made to ensure proper management of the technology for optimum benefits.

Take –Home Message

Having listened to this lengthy lecture, what message would you take home? First, we must realize that food is important and therefore food production must be given priority. How, in a nut shell, is genetics able to contribute to food security? Genetics is the basic science that can be applied for the production of improved planting materials. The quality of seeds used by farmers determines the upper limits of the efficiency of all other inputs (fertilizer, pesticides, implements, management practices etc.). There is no agricultural practice that can improve crop yield beyond the limits set by the quality of seeds used. The type of seed planted determines the type of harvest obtained. The use of improved seeds ensures greater harvests and bigger profits for farmers under the same management systems. The economic benefits derived from improved seeds are much higher than the price paid for them. Improved seeds provide reliable insurance for abundant food production, national food security and food for all.

Through genetic engineering, the following wonder crops have been produced- Event 176 or Maximizer (Bt 176 maize.), rice varieties like Golden rice, liberty link, Roundup ready, Kinuhikari low allergin, Nipponbare to mention just a few. The Golden Rice for instance, holds the potential to significantly expand the nutritional solution available to the poorest of the poor. Genes from daffodil for beta-carotene production and genes from bacteria for iron accumulation were incorporated into ordinary rice. This high vitamin A/high iron GM rice is called the Golden rice. Genetic engineering has also incorporated vaccines into fruits, thereby facilitating the vaccination of people in backward countries where facilities for storage, distribution and application of vaccines by injection or oral form do not often exist. This is science in action. We will not remain nonchalant and watch others soar to greater heights in science. As an

Institution, our University should play the role of a catalyst by providing an enabling environment for research. The GMOs that are now world-wide phenomena originated from Universities and Research Centres. If we create a transgenic crop or animal it will make great news in the world and our University will not be left out in the 2009 ranking of Universities. We are not too far away from realizing this goal. The novel crop varieties I developed are products from conventional hybridization and selection. If the oracle in the village could pull down an iroko tree with bare hands, one could imagine the extent it will go if it is armed with a small knife. Therefore, if a small laboratory is equipped with the necessary biotech equipment I am very optimistic that we can develop some transgenic varieties. The major gain from such home based transgenic is that it will be free from the dreaded contaminants. To achieve this, we must be ready to show honest commitment towards research and shun lobbyists who are not interested in research but after personal gains. Today everybody, including red cap chiefs, is claiming expertise in biotechnology because it is the thing making news. If I may ask, how many of these men and women with this claim are knowledgeable enough and are willing to render selfless service in biotechnology? They will end up speaking grammar and University of Nigeria will be the loser at the long run. This is the primary reason why many projects have failed to meet the expectations of the people. Technological breakthrough is not tied to English language. One can use Igbo or Yoruba to achieve the desired goal after all many of the developed countries with good track record in technology use their indigenous languages.

Mr Vice-Chancellor Sir, please 'shine your eyes', there are very many lobbyists on campus. We require a solid research base both in skilled personnel and facilities to make meaningful impact. We are making some progress already but there is room for improvements. That our University could take a second position in research and development in the NUC organized Nigerian Universities Research and Development Fair of 2008 is an indicator of a very bright future. There is need for sensitization of the community and formation of a co-ordinating body to document significant research findings in the University. Another important element for meaningful research that is yearning for attention is power. The few analytical equipment in our laboratories require electricity to function. The use of power generating plants by individual Departments has turned our campus into a mini motor park because of noise. There are many non-functional stand-by power generating plants on campus. Sir, you will ever be remembered if some of these could be replaced or repaired.

As individuals, we have contributions to make to achieve food security. One can put up a request for improved seeds and plant a garden for his or her family. Take my house, as an example – I have assorted types of vegetable crops, including fruit and medicinal crops that are not readily available in the market. A well fed family is the pride of the community and the state.

As a professor of plant genetics and breeding, I have developed novel crop lines. The seeds and planting materials are available for intending farmers particularly retirees. However they cost money but they are not as expensive as GMOs.

Mr Vice-Chancellor Sir, distinguished professors and members of senate, my colleagues, friends, Lions and Lionesses, Ladies and gentlemen, I will like to conclude this inaugural lecture with the words Johnathan Swift wisely said in Gulliver's Travels, 1726 "**And he gave it for his opinion that whoever could make two ears of corn or two blades of grass to grow upon a spot of ground where only one grew before, would deserve better of mankind, and do more essential service to his country than the whole race of politicians put together".**

Thank you and God bless you

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