WHAT HAVE I DONE AS AN AGRICULTURAL SCIENTIST?

BY

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(Achievements, Problems and Solution Proposals)

Mr. Vice-Chancellor. Deputy Vice-Chancellors. Fellow Academics, Lions and Lionesses, Distinguished Ladies and Gentlemen, I most sincerely thank the Vice-chancellor. Professor Chinedu Ositadima Nebo for approving that I deliver this inaugural lecture, which almost staled. However, when this lecture is over, I hope. it will be clear to some, if not all of us, why delivering this inaugural lecture at this point in time is important to me. I am, also, very glad to stand before you this afternoon to perform this very important academic function. In the process of writing this lecture, I discovered that after this lecture. I would become the first in our Faculty of Agriculture of over 44 years old, from the date of producing her first graduates, to deliver an inaugural lecture in this great University of Nigeria. This is for history and historians, but my prayer is for the inaugural lecture door, which I have opened for the Faculty today shall remain open for more inaugural lectures in the years ahead in Jesus name - Amen.

The Inaugural

Some people are aware of their vision in life and are guided by it in their life struggles. Others may not know they have a vision in life, but purse their "profession" to the best of their abilities successfully or unsuccessfully. I belong to the second category. I realized what could be defined as my vision in life during the *"Vision Alignment Workshop Programme"* organized by the University of Nigeria Administration in collaboration with the "Integrated Impact Consultants". Lagos. May 3-7, 2005. The programme was intended to encourage the staff and students of the University of Nigeria, Nsukka and Enugu Campuses, to be part of the on-going, campaign and reforms of the Chinedu Ositadinma Nnebo Administration to move the University forward. I participated in Group I of the five (5) Groups of the workshop. Each Group had morning and afternoon sessions, which lasted from l0a.m to 2 p.m., and 2 p.m. to 6.p.m, respectively, each day. The lecturer. Pastor Charles Achonwa, became aware of his vision in life when he was an undergraduate student of the University of Nigeria, and has since then pursued it to the level he was at the time of the workshop. His book "Vision Alignment" (power of personal and corporate purpose), is a part of the crystallization of Pastor Achonwa's practical guide and workbook for vision effectiveness,
and I may add. for myself, and those with me in the same category "vision realization". The book is designed to help individuals focus on their vision and vision, statement in many ways, and experience a revolutionary impact in their lives.

I told the lecturer that what I could identify as my vision in life was *passing examinations,* which I pursued from my days in the nursery school to today as a University Professor. It was on the same day that I

promised my self and the University Administration that I must deliver my "Inaugural Lecture" as a Professor of the University of Nigeria, Nsukka before my retirement as a final fulfillment of my vision. I figured that if I did not deliver my inaugural lecture, then my vision, which could be described as latent until May 3, 2005 would be impaired.

Having decided to present my inaugural lecture I ran into the problem of choosing a topic for the lecture. However, *ah anitio* I decided not choose a topic with a political bias, such as "Agriculture and Natural Development" OR "Nigerian Agriculture in the 21^{s1} Century" OR "Prospects and Problems of Agricultural Self-sufficiency in Nigeria" OR Inorganic and Organic Farming, which way Nigeria", *etc.* I finally settled on two topics to choose from. These are: (1) "WHAT HAVE I DONE AS AN AGRICULTURAL SCIENTIST'?" (Achievements, Problems and Solution Propsoals). and (2) "WHAT HAVE I DONE AS AN AGRICULTURAL SCIENTIST AND WHAT ABOUT YOU?"

I quickly realised that the number two (2) topic could be deduced from the topic number one (1). and I decided that the topic of my inaugural lecture should be "What have I done as an Agricultural Scientist? *(Achievements, Problems and Solutions Proposals)* I want you the listener or reader to add for yourself, "What about me?", irrespective of your profession or specialization.

How I became a Scientist

I was exposed to Arts and Science subjects during my secondary school education 1956-1963. Although, as students we had to complete our specialization, which is either Arts or Science, with science and arts balance, respectively, for the West African School Certificate (WASC) examinations. For those of us interested in science (interest here simply means "good"), were told, not counseled, that the professions available for those specializing in science at the Cambridge Higher School.

Certificate or Advanced level were, Agriculture. Medicine, Engineering and the basic sciences, Botany. Zoology, Chemistry. Physics, Mathematics, *etc.* At the Cambridge Higher School Certificate level, students with Botany, Zoology and Chemistry (Bo-Zoo-K) combination were Agricultural Sciences inclined. Those combining Botany, Zoology, Chemistry and Physics (Bo-Zoo-K-P) were Medical Sciences inclined, whereas those combining, Mathematics. Additional Mathematics and Physics (Maths-Maths-Physics) were inclined to Engineering. Also, 'ingle Honours Degrees in Botany, Zoology, Chemistry, Physics, Mathematics, were plausible and glamorous.

I opted during my Higher School Certificate programme to study a course, which combined Biology and Chemistry. Consequently, I majored in Botany, Zoology and Chemistry and obtained a Cambridge

Higher School Certificate in the three subjects in 1963/64. My first attempt to actualize my ambition was when 1 was offered admission to Study Plant/Soil Science at the University of Nigeria, Nsukka, in September, 1965. I could not pursue a Degree course in Plant/Soil Science to its logical conclusion because I was offered admission to read Agronomy at the University of Illinois. Urbana-Champaign, Illinois, U.S.A., under Johannes Von. Forester Foundation Scholarship a Youth Corper friend of mine, who died and was buried in Nigeria in 1965.

At the University of Illinois. Urbana-Champaign, I was able to register in the Agricultural Science programme of the Faculty of Agriculture. The programme enabled me to have a broader and firmer training in science subjects, especially in biology, chemistry and mathematics. There was flexibility in the programmes, which made it easy for students to register in courses outside their departmental core courses they feel useful in their training. At the completion of my bachelor of science (B.S) degree in Agricultural Science, I opted to do a Master of Science (M.S) degree in the Plant-Science option of the Department of Agronomy in the same University, specializing in plant breeding and genetics, with a minor in biochemistry. During this period, 1970/71 academic year, the research focus in the Department of Agronomy, and indeed in the similar Departments of most Corn Belt Universities of the Mid-Western United States of America, especially those at Purdue in Indiana, Ames in Iowa, East Lansing in Michigan, Columbus in Ohio, St. Louis in Missouri, *etc.*, was directed towards incorporating the gene, opaque-2 *($0_2 0_2$)* and floury-2 *($fl_2 fl_2$)* into the existing normal or local varieties of maize. The genes *$0_2 0_2$* and *$fl_2 fl_2$))* have been shown to improve the quality of maize protein (Emerson *el al.*, 1935; Mertz *el al.*, 1964 and Mertz, 1966). Bressani (1966) and Pickett (1966) showed that the opaque-2 maize protein was of superior quality to normal maize protein, and that the protein of opaque-2 maize compared favourably with milk protein (casein). Opaque-2 maize meal diet has about 90% protein quality and nutritional efficiency compared to milk (Bressani, 1966).

The programme became very attractive for the third world countries where **Kwashiorkor** (Ghanaian), a nutritional disease associated with poor quality or unbalanced protein diets, especially in the diets of growing or weaning babies and infants. In Nigeria for example, *"Akamu", "Ogi", "Agidi"* and *"Nni-Oka"* are popular baby food preparations from ground corn or maize *(Zea mays* L.). Normal or local maize cultivars used in these preparations are deficient in two essential amino acids, lysine and tryptophan. Amino acids are "essential" when an organism cannot synthesize the amino acids in question fast enough to meet the body requirements or cannot synthesize the amino acids at all.

Of all living organisms only plants and certain bacteria have the capabilities of synthesizing all the twenty (20) amino acids commonly found in proteins. However, a majority of the plants do not contain the ammo acids in the ratios required by man and other animals. This "phenomenon has concerned plant breeders, geneticists and nutritionists for many years. The deficiency of lysine and tryptophan in maize protein has resulted in negative nitrogen balance and poor growth of animals and humans fed on unbalanced maize meals.

Maize Breeding for Quality Protein

For every effective plant breeding programme, a breeder should have a *"genetic marker'* or any guide which should form the bases for phenotypic or genotypic selection of the desired trait or character i" question. The opaque-2 ($0_2 0_2$) and the floury-2 ($fl_2 fl_2$)) genes, which . responsible for increased lysine and tryptophan levels in maize prote and for improved quality of maize protein, also confer phc characteristics on maize seeds of opaque-2 and floury-2. which them from maize seeds without (hi2cnes. that is normal (+/+) maize seeds. Genotypically, maize seeds ofopaque-2 or floury-2 types could be identified from a normal maize seed by means of chemical analysis, using *Amino Acid Analyser, Microbiological Assay or 2, 4,* 6- Trimtroben'.ene-l-Sulfonic-Acid Assay.

A maize breeder or geneticist interested in increasing the levels of *lysine* and *fryptophan* in maize varieties is often faced with the problem of lack of a *fast, economical* and *accurate* method for the analysis of the limiting amino acids - lysine and tryptophan. The 2,4, 6-Trinitrobenzene-1-Sulfonic acid (TNBS) calorimetric method previously developed by Kakade and Liener (1969) and Subramanian *el al.* (1970) for the determination of lysine of foodstuffs was *not fast enough to handle fairly large numbers of samples and at the same time was not economical enough to meet the plant breeders' needs.* Consequently, in 1970/71, I set out to develop a *modified 2, 4, 6-Trinitrobenzene-l-Sulfonic Acid* (TNBS), method for use in the Department of Agronomy (Maize Breeding and Genetics Group), University of Illinois, Urbana-Champaign, Illinois, U.S.A.

Obi's 2,4,6-Trinitrobenzene-l-Sulfonic Acid (Obi's TNBS)

The lysine content in the protein from several varieties of maize was determined with the Obi's TNBS method (Obi, 1971 and 1982) and compared with those from Amino Acid Analyser (AAA) and Modified Microbiological Assay (MBA). The Obi's modified TNBS calorimetric method for lysine determination in maize seed protein was *economical to use, accurate and fast, and has been used to determine available lysine in large numbers of maize grains at the University of Illinois, Urbana-Champaign, Illinois, U.S.A., and the University of Nigeria. Nsukka,*

Nigeria. Protein, sufficiently representative of total protein, was extracted from samples ground in a water-cooled grinder. It was proposed that for samples with 15% protein content, the volume of NaOH-ETOH extractant be doubled. For maize samples with 15-30% oil content, 20 ml of acetone was used for fat extraction, as opposed to 15 ml of acetone used for samples with less than 15% oil content. The sub-sampling variation was not significant for the modified 2, 4, 6-trinitiobenzene-1-sulfonic acid (TNBS) method. The correlation coefficient between Ivsine values determined by the Amino Acid Analyser and the TNBS method for 90 opaque-2 maize samples was high (r =0.806), whereas tlie "r" value for TNBS and MBA was 0.596. Both r-values were, however, highly significant (p = 0.01). The coefficient of variation for TNBS was 6.5% against 12.6% for the Microbiological Assay (MBA), indicating that more variation was associated with the MBA than with the TNBS method. Consequently, Obi's method became the standard method for determining or estimating the Ivsine content of maize seed protein at the University of Illinois. Urbana-Champaign, Illinois, U.S.A. and the University of Nigeria, Nsukka, Nigeria.

Obi and Okiemute's Method for Zein Protein Fraction Determination in Maize Seeds

In our continuous search for still *cheaper* and *faster* method for selecting quality protein maize seeds and other cereals, such as, rice, sorghum, millet, wheat, *etc.*, we started the study, which was aimed at estimating the quantity of *zein* protein fraction of maize. Zein constitutes 50-55% of the total protein in the seed of normal maize (Rhodes and Jenkins, 1978). The percentage composition of other protein fractions in normal maize seed is; Albumins (4%). Globulins *{2%).* Glutelins (30-45%). The zein content of normal maize seed makes its protein quality poor, because zein contains low concentrations of 1ysine and tryptophan. Protein quality of maize seed can however, be altered by breeding and by improved agronomic practices, such as fertilizer application. For example, modified protein maize, the opaque-2 maize, has about 15% Albumins, 5% Globulins. 25% Prolamins (Zein). and 55% Glutelins (Rhodes and Jenkins, 1978). Zein can be used for industrial purposes such as in the manufacture of special fabrics (Jugenheimer, 1958), as well as various plastics, coating and lacquers (Houghton. 1977). A low or high zein content can be demanded depending on the use for which maize is intended. It becomes important, therefore, to develop a fast and cheap method for the analysis of zein content of maize protein for use in maize breeding and selection for low and high zein content maize genotypes.

We developed a fast and cheaper procedure for screening a large

number of maize cultivars for zein content in a maize-breeding programme. We observed that using potassium sulphate-ethanol procedure, the time for analysis of the maize samples was reduced by 20% and the cost by about 45% compared with the acetone-ethanol *procedure consistently extracted more zein than the acetone-ethanol method. The potassium sulphate-ethanol method gave a lower coefficient of variation than the ctone-ethanol in the content of zein extracted. When the zein content* was *expressed as percentage of protein content the two procedures gave closely similar results. There was a close positive correlation between zein content and zein content expressed as a percentage of total protein as determined by both procedures. It is, therefore, suggested that zein* values *expressed, as percentage of total protein should be used in ! ossifying maize cultivars for zein content in a breeding programme Obi and Okiemute, 1987).*

My Interview for a Lectureship Appointment at the University of Nigeria, Nsukka

When I started work at the University of Nigeria, Nsukka, two weeks after my arrival on March 29, 1975, and my official interview for the appointment as lecturer, I realized that I had to start my research on maize from a new beginning. This assured me that my answer on that issue during my interview was in order. During my interview I was asked to describe or tell the panel what I did for my Ph.D. research. After a long, and probably boring lecture, I image, on the topic, *"Physiological Mechanisms of Disease Resistance in Zea mays* L. *to Helmintliosporium fiingF,* a member of the panel asked me if I would continue the same line of research at the University of Nigeria, Nsukka. In my answer, I reminded the panel that I concluded my research a year before America's 200 years of independence, when Nigeria was getting ready to celebrate her 15 years of independence. I, however, told the panel that the situation on the ground in the Department would dictate where I would begin my research on maize.

When I visited the Department of Crop Science seed store I found the following eleven genotypes made up of five (5) cultivars; **Local White ex** UNN, **Amiacha White ex** UNN, **Local light Purple ex Bende,** and

six (6) composite varieties; **Popcorn White ex** UNN, **NCC ex** UNN, **composite** A, **ex** UNN, N.S.5 **ex** UNN, **Western White I ex** UNN and Western **White II ex** UNN.

I brought back from my Department at Urbana-Champaign. Illinois, U.S.A fourteen (14) genotypes made up of Illinois High Protein (IHP), Opaque-2 and Floury-2 breeding lines. The identification of these genotypes as shown above was necessary to distinguish them from new germ-plasms to be introduced later into the collection.

As an Agricultural Scientist. I devoted my time and energy in

research in the areas of maize improvement, especially in quality protein maize (QPM). quality and quantity starch (amylose and amylopectin), increased and decreased oil contents of maize and physiological mechanisms of disease resistance in maize involving the production. characterization and identification of "gene" products in host - pathogen interaction in plants called "phytoalexins". My research interest, also extended to Applied Statistics in Agricultural and Biological Research. especially in the areas of appropriate *"'mean separation'"* or *"detection of differences between treatment or effect means"* procedures, search for appropriate statistical model(s) for time of planting experiments, factorial designs and factorial experiments, including Split-plot and Nested Designs, Studies of Residual Analysis for the dictation of outliers in experiments, involving Completely Randomized Design (CRD). Randomized Complete Block Design (RCBD) and Latin Square Design. Finally, a proposal was made involving, "Analysis of Absolute Values of Residuals to Test Distributional Assumptions of Linear Models for Balanced Designs of CRD, RCBD and Latin Square Design". Therefore, this lecture is intended to address, *"where I am coming from*", *"'Where I am"* and *"Where you and I will be going with maize and applied statistics in agricultural, biological and others areas of research',* as an agricultural scientist. Also, I discussed the progress we have made when my plant breeding and genetics researches "wing-flapped" into other crops, namely: Rice, *"Egusi"* melon. Plantain, and *"Utasi"*. Finally, I will peep into the future of *Curricula,* lecture handouts, researches by staff and postgraduate students, staff development, indiscipline in the University of Nigeria and other Nigerian Universities, and career positions of Vice-Chancellors, Deans, Directors and Heads.

My Research Programmes at the University of Nigeria, Nsukka

Maize *(Zea mays* L.) provides, worldwide, over 20 million tonnes of protein to humans annually (Anon. 1967). In Africa, maize consumption could account for about 64% of the total daily calorie intake of the rural dwellers, especially during the "hunger period". In Southern Nigeria.
maize has been the principal cultivated cereal until the introduction of rice *(Oryza saliva* L.). and has been used primarily for human food. Maize consumption in Western States of Nigeria varies from 2.6 to 2.8kg per person per week (Agboola, 1979). In the Eastern States. Abakaliki area was identified to be the highest consumer of maize diets, which was estimated at 0.5kg per person per week (Agboola, 1979).

Protein is an expensive but necessary constituent of human food. It constitutes about 10-11% of the whole maize kernel, and most of the nitrogen in maize is present in the form of protein. Relatively small

amounts of non-protein nitrogen are found in maize and over 50% of this non-protein, nitrogen is in the form of amino-acids (Samuel, 1969).

Maize Germ plasm Collection

Under a Senate Grant Number 00209/76, Drs I.U. Obi (Leader, now Prof. I.U. Obi). B.N. Okwuosa (now late) and O.C. Nwankiti (now retired as Professor) of the Departments of Crop Science. Animal Science and Botany, respectively were able to collect oxer 230 cultivars of maize from Anambra (now includes, Ebonyi and Enugu), Imo (now includes, Abia), Bendel (now includes, Delta and Edo), Benue (now includes, Kogi, Samfara and Taraba), Cross River (now includes, Akwa-Ibom), Oyo (includes, Oshun), and Kaduna States of Nigeria. To these were added twenty-four (24) improved varieties as check or control varieties from Oyo, Anambra and Urbana, Illinois. U.S.A. These collections were analysed for percentage total crude protein, gm lysine/l00gm sample, lysine/protein ratio, amylose. amylopeclin and oil content. The results are summarized in Tables 1, 2. 3, 4, 5, 6, 7 and 8 and from these results the following conclusions were made:

Survey of Nigerian Local Maize for Protein Content

The percentage protein content of Nigerian local maize cultivars studied ranged from 6.27 *to 16.63% with a mean, range and mode of 9.02. 10.36 and* 7.72%, *respectively. These values were lower than those obtained/or the improved varieties which had a mean. range and mode of 12.80, 23.2} and 14.00% protein, respectively and ranged from 7.00 to 30.21% (Table 1).* These findings were to be expected from a maize population that was not selected for high protein content. The results revealed that maize collections from Benue (8.33% protein) and Cross River (8.82% protein) had lower mean percentage protein content than those from Anambra (9.4% protein), Bendel (10.15% protein) and Imo (9.50%) protein) States of Nigeria. The differences in percentage protein content of the cultivars between States were statistically non-significant (Tables 2 and 3). However, it could be inferred that Anambra, Bendel and Imo States were better suited for production of maize with high protein content. Therefore, faster advances in selection of high protein content could be made with the maize germ-plasm from Anambra, Bendel and Imo State Obi *et al.* (1988).

Survey of Nigerian Local Maize for Lysine/Protein Ratio (gm Lysine/l00gm Protein)

The results of these preliminary analyses for lysine and total protein of some Nigerian local and exotic maize collections (Tables 4 and 5) show very interesting distributions of percent total protein and lysine contents of the normal (+/+) and high lysine *($0_2 0_2$)* maize lines, varieties

and cultivars (Obi, 1977). Some of the normal (+/+) maize genotypes (Table 5) compared favourably with the high lysine *($0_2 0_2$)* lines in gm lysine per l00gm of protein (L/p ratio). The percentage total protein ranged from 7.00 to 30.21%, whereas the lysine content, the L/P ratio ranged from 0.71 to 3.43gm. Bressani (1966) showed the promotion of growth of humans by Opaque-2 maize diet. Also, Jensen *et al.* (1966) and Mertz *et al.* (1966) showed that Opaque-2 maize protein promoted growth of swine and rats, respectively.

Survey of Nigeria Local Maize for Amylose, Amylopectin and Oil Contents

Two hundred samples made up of 54 improved and 146 unimproved cultivars from Anambra (now includes, Ebonyi and Enugu), Bendel (now includes, Edo and Delta), Benue (now includes, Kogi, Samfara and Taraba), Imo (now includes, Abia), Cross River (now includes, Akwa-Ibom), Kaduna, and Oyo (now includes, Oshun), States were analysed for amylose, amylopectin and oil contents. For plant breeding purposes, we classified the 200 maize genotypes assayed into three broad groups as *low, medium* and *high* oil, amylose and amylopectin contents (Table 6).

The content of amylose varied between 13 and 37.5% while amylopectin content ranged from 62.5 to 87% for the unimproved cultivars. The improved cultivars had 13 to 35% amylose and 65 to 87% amylopectin. The results also showed a range of 2.7 to 8.7% oil in the unimproved and 2.4 to 7.9% in the improved cultivars (Table 7).

Mean oil content ranged from 6.60% in the maize samples from Kaduna State through 5.01% for Imo to 3.84% for Bendel State samples. Oil content in maize samples from Oyo. Benue. Anambra. and Cross River States were 4.91, 4.80, 4.47 and 3.93%, respectively, which were intermediate in oil content.

The maize samples from Cross River, and Bendel States, which had the lowest oil content had significantly higher amylose content of 29.57 and 29.15%, respectively. Amylopectin content varied between 76.27 and 70.43% in all samples, although maize from Oyo and Benue States had the highest concentration of amylopectin (Table 8).

More than 70 per cent of all maize cultivars assayed contained medium levels of amylose, amylopectin and oil. Less than 20 per cent contained high concentrations of these three compounds, which suggested that substantial improvement could be made in breeding for high concentrations of these compounds in Nigerian maize.

The distribution of the three compounds followed a 3:10:1 for oil and 1:9:2 and 2:9:1 for amylose and amylopectin, respectively. A Chi-square goodness of fit test on the 3:10:1 ratio for oil 1:9:2 for amylose and 2:9:1 for amylopectin on the *low, medium* and *high* classifications of the three compounds was satisfactory. This implied that out of every 200 maize

genotypes analysed, *three* samples would have *low* oil, *ten (10)* would have *medium* oil and *one* sample would have *high* oil. Similarly, for Amylose and Amylopectin the frequencies would be 1:9:2 and 2:9:1, for *low, medium* and *high* contents, respectively. These ratios were considered appropriate considering the fact that the population under study had not been selected for *oil, amylose* and *amylopectin.*

Table 1: Mean, Range, Mode and Standard Error of Percent Crude Protein in 230 Local and 24 Improved Varieties of Maize

Maize Cultivars	Mean	Range	Mode	S.E.
Improved	12.80	23.21	14.0	1.15
Unimproved	9.02	10.36	7.72	1.64

Table 2: Mean, Percent Protein of 230 Local Maize Cultivars from Six States of Nigeria

State of Origin	Crude Protein (%)
Anambra (now Anambra, Ebonyi and Enugu)	9.64
Bendel (now Edo and Delta)	10.15
Benue (now Benue and Kogi)*	8.33
Cross River (now Cross River and Akwa-Ibom)	8.82
Imo (now Imo and Abia)	9.5
Kaduna**	10.50

* *Ports of Sandara and Taraba States*
** *Only one sample was available for analysis*

Table 3: Mean Percent Protein in 230 Local Maize Cultivars from Different States of Nigeria Based on the Major Seed Colours

State	Yellow	White	Mean (†)
Anambra (now Anambra, Ebonyi and Enugu)	8.72	10.55	9.64
Imo (now Imo and Abia)	10.12	8.87	9.50
Cross River (now Cross River and Akwa-Ibom)	9.26	8.36	8.82
Bendel (now Edo and Delta)	9.99	10.30	10.15
Benue (now Benue and Kogi)	8.15	8.50	8.33

† *Mean differences are statistically non-significant as determined by a preliminary F-test.*

Table 4: Percent Total Protein, gm Lysine/100gm Sample and gm Lysine/100gm Protein (L/P ratio) of 44 Lines and Cultivars of Maize in Nsukka Germ Plasm Collection Bank (Obi, 1977 and 1991)

S/No.	Pedigree	% Total Protein	gm Lysine/ 100gm Sample	L/P Ratio
1.	Local White No. ex. U.N.N.	14.88	0.216	1.45
2.	Amiacha White ex. U.N.N.	16.63	0.208	1.25
3.	Local Light Purple ex. U.N.N.	12.25	0.224	1.83
4.	Local Yellow ex. U.N.N.	11.38	0.184	1.62
5.	Lagos White 76 ⊗-1	9.63	0.184	1.91
6.	Ibagwa 76 ⊗-2	12.25	0.184	1.50
7.	Local Dark Purple 76 ⊗-2	10.50	0.210	2.00
8.	Local Purple ex. Bende	10.50	0.194	1.85
9.	Opi-75 White	14.50	0.176	1.26
10.	Orba-75 Yellow	7.88	0.184	2.34
11.	Ibagwa 75 ⊗-1	14.00	0.172	2.23
12.	Popcorn White 76 ⊗-2	12.25	0.240	1.96
13.	Popcorn White ex. U.N.N.	8.75	0.184	2.10
14.	Popcorn White ex. U.N.N. 76 ⊗-1	15.75	0.200	1.27
15.	Popcorn Yellow	10.50	0.192	1.83
16.	Samaru 1,2,3, ex. A.B.U.	10.50	0.224	2.13
17.	N.C.C. ex. U.N.N.	14.00	0.200	1.43
18.	TZB Normal I.I.T.A.	14.00	0.186	1.33
19.	Eafm 231	10.50	-	-
20.	P X B 101	9.63	0.192	1.99
21.	NCBRb ex. Moor Plantation	7.00	0.240	3.43
22.	NCBRbU ex. Moor Plantation	7.00	0.192	2.74
23.	Composite A_1 ex. U.N.N.	8.75	0.224	2.55
24.	NCBRb x NCARb	9.63	0.156	1.63
25.	NCARb x Moor Plantation	8.75	0.192	2.19
26.	N.S. 5 ex. U.N.N. (1975)	12.25	0.194	1.58
27.	NCBRbO_2U ex. Moor Plantation	10.50	0.307	2.92
28.	Western White I ex. U.N.N.	12.25	0.269	2.20
29.	Western White II ex. U.N.N.	9.63	0.241	2.50
30	Illinois High Protein (1975) USA	28.46	0.241	0.85

Table 4 Cont'd

31.	R802AO$_2$O$_2$ (41029) USA	14.00	0.250	1.79
32.	Syn. D.O. O$_2$O$_2$ USA	8.75	0.260	2.97
33.	W64O-O$_2$ (41030) USA	14.00	0.279	1.99
34.	72 33 x 46 USA	11.38	0.216	1.90
36.	R802fl-fl$_2$ (2-1682-2) USA	10.50	0.227	2.13
37.	TZBO.O2 (76 ⊗-1) ex. IITA	15.75	0.298	1.89
38.	R802fl$_2$fl$_2$ (41038) USA	13.12	0.291	2.24
39.	R802fl$_2$fl$_2$ (2-1682-2) USA	14.00	0.241	1.72
40.	SSSS/O$_2$O$_2$ USA	13.12	0.253	1.92
41.	O$_2$O$_2$/fl$_2$fl$_2$ USA	9.63	0.241	2.50
42.	TZBO-O$_2$ ex. IITA	11.38	0.298	2.62
43.	Ob45O-O$_2$ (41025) USA	10.50	0.379	2.66

Table 5: Comparison of Percent Total Protein and L/P Ratios of Nine Normal and High Lysine Maize Lines/Varieties in the Nsukka Maize Breeding Programme (Obi, 1977 and 1991)

S/No.	Pedigree		% Total Protein	L/P Ratio
1.	Oba - 75 Yellow	(N)	7.88	2.34
2.	Popcorn White ex. U.N.N.	(N)	8.75	2.10
3.	Composite A , ex. U.N.N.	(N)	8.75	2.55
4.	Samaru 1,2,3, ex. A.B.U.	(N)	10.50	2.13
5.	NCBRb ex. Moor Plantation	(N)	7.00	3.40
6.	NCBRbU ex. Moor Plantation	(N)	7.88	2.74
7.	NCARb ex. Moor Plantation	(N)	8.75	2.19
8.	Western White I ex. U.N.N.	(N)	12.25	2.20
9.	Western White II ex. U.N.N.	(N)	9.63	2.50
10.	NCBRbO$_2$O$_2$U ex. Moor Plantation	(HL)	10.50	2.92
11.	TZBO$_2$O$_2$ ex. IITA	(HL)	11.38	2.62
12.	R802AO$_2$O$_2$ (41030) U.S.A.	(HL)	14.00	1.79
13.	R802fl$_2$fl$_2$ (41038) U.S.A.	(HL)	13.12	2.24
14.	R802fl$_2$fl$_2$ (2-1682-2) U.S.A.	(HL)	14.00	2.13
15.	Ob45O-O$_2$ U.S.A.	(HL)	10.50	2.66
16.	O$_2$O$_2$/fl$_2$fl$_2$ U.S.A.	(HL)	9.63	3.50
17.	Syn. D.O. O$_2$O$_2$ U.S.A.	(HL)	8.75	2.97
18.	W64AO-O$_2$ (41030) U.S.A.	(HL)	14.00	1.99

(N) = Normal Maize, (HL) = High Lysine Maize

Table 6: Classification of Nigerian Local Maize Cultivars/Genotypes into Low, Medium and High Oil, Amylose and Amylopectin Groups for a Breeding Programme

Constituent	Classes in Percent Content		
	Low	Medium	High
Oil	< 4	4 - 6	> 6
Amylose	< 20	20 - 30	> 30
Amylopectin	< 70	70 - 80	> 80

Source: Obi and Ihecigbo (1987)

Table 7: Mean, Range, Mode and Standard Error (S.E) of Prevent Oil, Amylose and Amylopectin Content of 146 Unimproved and 54 Improved Cultivars of Maize

Percent Composition	*Maize Cultivars*							
	Unimproved				*Improved*			
	Mean	Range	Mode	S.E	Mean	Range	Mode	S.E.
Oil	4.36	6.0	4.0	0.10	5.04	5.5	5.1	0.41
Amylose	26.62	24.5	25.0	0.31	24.12	22.0	25.0	0.71
Amylopectin	73.38	24.5	75.0	0.31	75.88	22.0	75.0	0.71

Table 8: Mean, Percent Oil, Amylose and Amylopectin Content of 200 Cultivars of Maize (Improved and Unimproved) from Seven States of Nigeria

State[a)]	Oil (%)	Amylose (%)	Amylopectin (%)
Anambra	4.47	25.81	74.19
Bendel	3.84	29.15	70.85
Benue	4.80	24.10	75.81
Cross River	3.93	29.57	70.43
Imo	5.01	26.63	75.37
Kaduna	6.60	24.63	75.37
Oyo	4.91	23.73	76.27
$LSD_{(0.05)}$	0.95	2.43	2.43

a) Anambra (now includes Ebonyi and Enugu), Bendel (now includes Delta and Edo), Benue (now includes Kogi and parts of Sanfara and Taraba), Cross River (now includes Akwa Ibom), Imo (now includes Abia), Kaduna (now includes parts of Oyo) now includes parts of Oshun.

Reciprocal Recurrent Selection for Increased Protein, Oil, Amylose and Amylopectin Contents of Two Populations of Maize *(Zea mays* L.)

In 1987 we designed a Reciprocal Recurrent Selection using the procedures outlined by Comstock *et al.* (1949), with minor modifications. We used four open pollinated varieties, namely; ***DMR-ESR-Y, EV-8431-SR-BC4***, ***DMR-ESR-W*** and ***IK(1)-8149-SR-BC2,*** which were named population A. On the other hand, four (4) open-pollinated late maturing maize varieties, namely; ***DMR-LSR-Y***, ***West-Yellow-M_2, TZB-SR*** and ***DMR-LSR-W*** represented population B. Both populations A and B were assumed to be genetically variable, based on time of maturity, protein, oil, amylose, amylopectin, and plant and ear heights.

After two years, which coincided with the end of \\\e *first cycle* of the programme, we observed the following results; which were summarized and recommended as follows:

After the first cycle of reciprocal recurrent selection for protein, oil, amylose and amylopectin between open-pollinated early and late maturing populations of maize, protein content increased from 8.74 to 11.01 per cent, showing a mid-parent heterosis of 26.00 per cent. The mean protein content of the selected high protein population decreased by 0.66 per cent.

The mean oil content only increased from 5.19 to 5.42 per cent showing a mid parent heterosis of 4.43 per cent. Oil content increased by 0.54 per cent in high oil selection but decreased by 1.97 per cent to 3.22 per cent in the low oil selection.

The mean amylose content of the selected high amylose was 22.10 per cent, while that of low amylose was 18.30 per cent, a decrease of 6.00 per cent. On the other hand, the mean amylopectin content of the selected high amylopectin was 78.70 per cent, an increase of 3.80 per cent. The progress so far made is normal and encouraging to justify continuation of the programme (Onyishi and Obi, 1990).

Evaluation of Progenies ol Second Cycle of a Recurrent Selection tor Increased and for a Decreased Oil Contents of Nigeria Local Maize *(Zea mays* L.)

Alexander (1987), briefly summarized the history of maize breeding programme by Hopkins (1986) at Urbana, Illinois, U.S.A., aimed at producing high protein and high oil seeds. Presently, in the same Urbana programme, protein has gone from 10 to 32%, and to a low of 5%. Similarly, oil has moved from 4.5 to 21%, and to 0.5% in the low strain. Alexander (1987). pointed out that A.L. Jensen and C.M. Parsons independently showed that corn hybrids of 8-10% oil content produced better live weight gains per unit of feed than ordinary types of corn. In the same strains of corn, protein levels were generally one or more percentage points greater and often with improved quality. Parson, according to Alexander (1987), observed that broilers and laying hens could use corn of higher oil content to advantage.

The amount of oil in maize is primarily under genetic control (Inglett, 1970). About 20 or more genes condition oil content in maize (Sprague and Brimhall, 1949). These genes have small and approximately equal additive effects and distributed more or less at random over the 10 pairs of maize chromosomes. Another proposition is that oil is conditioned by one or more genes linked with the ***wx*** region of chromosome 9. and at least one gene with a 4-7a interchange. Differences in the level oflinoleic acid. *vis-a-vis,* the quality of oil in the Illinois High Oil (IHO), and ***R84*** strains of corn may be controlled by a single locus designated ***In***. This was confirmed by Roche *el al.* (197 la).

Corn oil is concentrated in the germ and in the alenrone layer. It is a significant and good source of linoleic acid ***($CH_2CH_2)_4$ (CH = CH CN2)2*** *(CH2)6* ***COOH),*** oleic acid ***(CH_2*** *(CN_2)7* ***COOH)*** which are essential and unsaturated fatty acids. Other essential and unsaturated fatty acids present in maize seeds, but in smaller amounts are: Linolenic acid ***(CH_3CH_2(CH = $CHCH_3)_3$*** *($CH_2)_6$ COOH* and, arachidonic acid ***($CH_3(CH_2)_4$ (CH = $CHCH_2)_4$*** *($CH_2)_2$* ***COOH*** (Table 9). Linoleic, linolenic and other unsaturated fatty acids are essential food components in form of vitamin F, which is the designation of essential fatty acids.

Normal maize, unimproved for high oil composition, on the average, contains 13.47% palmitic acid, 2.23% stearic acid. 46.15% linoleic acid, 36.09% oleic acid, 1.18% linolenic acid and about 0.79% arachidonic acid (Table 9). In breeding for high and good quality corn oil the realistic goal is to increase the linoleic acid content to 60% of the total oil content (Alexander, 1970). Quality of oil is associated with the relative amount of the linoleic acid (18:2) in the triglycerides. The higher the relative amount of linoleic acid the higher the oil quality (Alexander. 1970). Also, percentage and relative concentration of tryptophan in the whole kernel was positively correlated with percentage oil content suggesting that increased oil percentage may also increase percentage of relatively

high quality protein in corn grain (Sprague and Brimhall unpublished data in Miller and Brimhall, 1951).

Maize is primarily carbohydrate, and an excellent raw material for alcohol production. Maize of low oil content may be preferred in brewing especially in beer production. Chemically, maize contains approximately 80% carbohydrate, 10% protein, 4.5% oil, 5% fibre and 2% minerals (Creech and Alexander, 1978). An improvement in the chemical constituents of maize would, therefore, be of great advantage for human consumption, livestock feed and other agro-based industries. Maize oil can be used as cooking oil, in bakery products, oleomargarine, salad dressing, pharmaceuticals and shortenings. Non-food uses of refined corn oil include ammunition, chemicals, paints, varnishes, rubber substitutes, rust preventives, soaps, textiles, paper, powder, *etc.*

The nutritional properties of refined maize oil make it a valuable food that is easy to digest. Berkhout (1968), revealed that pure refined maize oil has a very important nutritional characteristics when used in human food. Predominance of glycerides of linoleic acid and the high glycerides content in the unsaturated acid (84-85%), render it valuable in reducing the serum cholesterol level in blood, the high level of which he associated with arteriosclerosis and coronary heart diseases. The results in Table 9 show that the ratios of unsaturated to saturated fatty acids fitted a 5:1 ratio in maize ($\wedge^2$ = 3.02, P-value 0.06-0.08); a 6:1 ratio in groundnut (*f* = 2.29, P-value = 0.12-0.15) and 1:1 ratio in oil palm ($\wedge^2$ = 0.109. P-value = 0.65-0.75). These ratios correspond to 84 - 85%, 80 - 85% and 52 - 53% of unsaturated fatty acids in maize, groundnut and oil palm, respectively. It is, therefore, apparent that maize and groundnut oils are superior to oils of palm oil on the basis of percentage compositions of unsaturated fatty acids. Similarly, corn oil is of superior quality to groundnut and palm oils in their percentage contents of linoleic acid, which is approximately 469c fur maize. 21% for groundnul and 10% for palm oil.

Corn oil is, therefore, premium oil and regularly were valuable than starch, and at current market prices, corn oil is worth approximately four times as much as corn starch on weight basis. This relationship could encourage millers to seek for corn varieties higher in oil, for processing into vegetable oil for industrial and domestic uses.

In Nigeria, oil palm dominated other crop plants as source of oil for humans and industries in the early thirties up to the late sixties. In recent times the supply of oil from oil palm has dwindled, and has been irregular requiring a rethinking on the nation's over reliance on oil palm and groundnut as sources of domestic and industrial vegetable oils. It becomes pertinent, therefore, that order sources of quantity and quality oil for domestic and industrial uses be explored in keeping with the agro-

economic realities of Nigeria as a nation. It is on basis of these needs that we screened the Nigerian local maize cultivars for oil contents (Obi and Ihedigbo, 1987), to form the source population for a phenotypic recurrent selection for increased and decreased oil contents of maize.

We started the phenotypic recurrent programme in 1988 and after the *second cycle* of a phenotypic recurrent selection we were able to summarize and recommend as follows:

At the completion of the *first year* of the *second cycle* of a phenotypic recurrent selection for increased and decreased oil content in a population of Nigerian local maize cultivars, the percentage oil distribution was *slightly skewed* to the right, *plaiykurtic* and peaked between 5.6 and 6.5% and with a mode of 6.9% oil contents. The mean oil content was 6.13%, which was approximately 18% over the mean of the initial population of 5% oil content. Maize "strains" with low oil content of 3.3% were identified and this corresponded to a decrease of 34% over the mean oil content of the initial population. The range of oil content in the advanced population was 3.3 - 9.7%. The progenies had considerable variation with a range of 6.4% indicating more progress with advancing generations (Obi, 1988).

Rapid progress for increased oil content were made if seeds for planting and oil determinations were taken from the *base* and *middle* portions of the ear, divided and classified into three equal portions of *base, middle* and *tip.* It is possible using this programme to develop inbred lines. varieties and In hrids of maize to satisfy specific needs of maize processors like breweries, wet and dry millers, for good quality foods, feed and other consumers of **maize** based products.

Table 9: Percentage Distribution of Saturated and Unsaturated Fatty Acids in Maize *[Zea **mays*** L.), **Oil Palm** *(Elaesis giiineensis),* **and Groundnut** *{Arachis hypogea)*

Fatty Acids	Saturation	Maize	Oil Palm	Groundnut
Linoleic	Unsaturated	46.15[110]	9.60	21.00(20.00)[(b,
Oleic	Unsaturated	36.09	42.50	59.00 (62.00)
Linolenic	Unsaturated	1.18	-	-
Arachidonic	Unsaturated	0.79	-	-
Sub-total		84.21	52.10	80(82)
Palmitic	Saturated	13.47	41.20	9.00(13.00)
Stearic	Saturated	2.23	4.30	-
Myristic	Saturated	-	2.30	-
Sub-total		15.70	47.80	9.00(13.00)
Grand Total		99.91	99.90	89.00(95.00)

Source: Maize: Genter *et nl.* (1956) Oil

Pa]m;0tcdoh(1974) Groundnut; R obinson
(1967), and Ononogbu (1988)

a) All figures are approximate percentage by weight
b) Figures in brackets arc as reported by Ononogbu. 1988.

Variability in Chemical Composition of Maize *(Zea mays* L.) After on Season of Intercrossing and Random-Mating in a Phenotypic Recurrent Selection

Many genes have been shown to alter carbohydrate types and quantity during kernel development. Bear (1958), found a simple recessive gene, designated *ae-gene* (the amylose extender gene), that changed the amylose-amylopectin ratio from 1:3 to 1:1 in mature maize endosperm without reducing the total starch content. This confirmed

maize has been the principal cultivated cereal until the introduction of rice *(Oryzci saliva* L.), and has been used primarily for human food. Maize consumption in Western States of Nigeria varies from 2.6 to 2.8kg per person per week (Agboola, 1979). In the Eastern States, Abakaliki area was identified to be the highest consumer of maize diets, which was estimated at 0.5kg per person per week (Agboola. 1979).

Protein is an expensive but necessary constituent of human food. It constitutes about 10-11% of the whole maize kernel, and most of the nitrogen in maize is present in the form of protein. Relatively small amounts of non-protein nitrogen are found in maize and over 50% of this non-protein, nitrogen is in the form ofamino-acids (Samuel, 1969).

earlier report by Deatheragc *el al.* (1954), that the *ae-gene* produced higher proportions of amylose without substantial reduction in total starch. The **ae**-gene can be used to produce starch with 55-77% amylose Creech *et al.,* 1963). It provided the basis for development of amylo-maize, a hybrid with 50% and more amylose starch content. Modifier genes in the presence of *ae-gene* may further alter the percentage of amylose along a nearly continuous scale (Loesch and Zuber, 1964). Cameron (1947), reported that the genes sugary-1 *(siti)* and dull *(dii)* interact to increase the amylose content to approximately 65% while the genes ***du, su*** and $\mathbf{Su_2}$ (sugary-2), interact to increase the amylose content of starch to 77%.

Many gene mutations in corn have been shown to affect endosperm carbohydrate components. The waxy (**wx**)-gene contained mainly amylopectin (Sprague *et al.,* 1943). The shrunken-1 ($\mathbf{sh_1}$)-gene reduces the starch content of the endosperm (Hutchinson, 1921). The s^-gene had similar but distinct effect. The sh_2-gene causes an accumulation of sugars and a corresponding decrease in endosperm starch (Laughnan, 1953). Similarly, the brittle-1 *(bt_1)* and bt_2-genes reduce endosperm starch with

the accumulation of water-soluble polysaccharides (WSP). The gene *ae* is epistatic to *siii-gene* in that less reducing sugars were present in *ae siii* genotype than in the **su_1** alone. Similarly, the du_2 genotype had less reducing sugars than the sh_2 Both su_2 and *wx-gene* seemed to intensify the effect of su_1-gene in accumulating sugars.

The experiment was designed to estimate the amount of variability in the chemical contents of maize after one season of *intercrossing* and *random-mating* in a phenotypic recurrent selection programme. The samples used in the studies were two portions of selfed seeds from: *intercrossed* and *bulked seeds* of *the first cycle* of recurrent selection and *intercrossed* and *bulked seeds of* the *first cycle* of recurrent selection, which were allowed one season of *random-mating.* In all 84 selfed maize cobs were selected, 42 from each population, and were subjected to chemical analysis for protein, oil. amylose and amylopecting contents. Protein was determined by the standard Kjeldahl procedure using the formula Kj N x 6.25, whereas oil. amylose and amylopectin contents were determined as describe by Obi and Ihedigbo (1987).

From the studies the following results and recommendations were made. The ***randomly-mated*** maize population contained 6.8% protein compared with 7.5% in the *intercrossed* pupukilion. The mean oil content for the intercrossed population was 7.1%, which was approximately 2% greater than 5.2% mean oil in the *randomly-mated* population. The mean amylose and amylopectin contents were 21.4 and 78.6%, respectively, in the *intercrossed* population, while the mean percentage amylose and amylopectin contents of the *randomly-mated* population were 22.2 and *11 .Wo,* respectively.

Generally, grains at the ***base*** and ***middle*** portions of the ear had 0.57% more protein. 6.4% more oil and 1.30% more amylose than those at the ***tip.*** Rapid progress in selection for increased protein; oil and amylose could be made if seeds were taken from the ***base*** and ***middle*** portions of the ear rather the ***tip.***

The *intercrossed* population had a coefficient of variation for protein, oil amylose and amylopectin of 34.56, 13.37, 5.67 and 7.85 per cent, while the corresponding values in the *randomly-mated* population were 9.24, 17.37, 4.37 and 2.76 per cent, respectively. *Intercrossing* increased the variability in all the component fractions, except oil content where *random-mating* showed greater variability (17.37%)) compared with *intercrossing* (13.37%). *Random-mating* is. therefore, not recommended as a means of rapidly increasing the percentage content of the various components studied.

Optimum Rates of N,P,K for Hybrid Maize Production in the Derived Savanna Zone of Southeastern Nigeria

When the hybrid maize was produced and released to Nigerian

farmers in the mid nineteen eights (mid 80's) we decided to find out the NPK requirement for the hybrid varieties in the derived savanna zone of southeastern Nigeria. A 4 x 3 x 3 factorial design in a Randomized Complete Black Design (RCBD), of three blocks was used. The mean grain yield data due to the main effects of nitrogen and phosphorus were fitted to the quadratic curve of the form $Y = a + bx + cx^2$, while the data due to potassium effect was fitted to a simple linear regression equation of the form $Y = a + bx$. In the two equations the "Y" is the response or dependent variable, "a" is the intercept of the regression line and "b" and "c" are the slopes of the regression line. Also, we determined the economic rates of N, P and K using equation of Uzo (1976), which states that:

$X_0 = \frac{b\overset{Q}{Z}}{-\ 2C}$ Where x_o = rate of N, P_2O_5 and K_2O

Q = Cost/kg of N, P_2O_5 of N, P_2O_5 and K_2O and Z = value of produce/metric tonne of maize. The response of nitrogen and phosphorus were signifantly ($P<0.05$) quadratic, and the equations were:

$Y_n = 3.06 + 0.00771X_N - 0.000243X^2_3$, and

$Y_P = 2.09 + 0.066XX_P - 0.000704\ X^2_P$ for nitrogen and P_2O_5 respectively.

On the other hand, the Potassium (KO) fitted significantly ($P < .05$), a simple linear regression and the estimated parameters and the equation were as follows.

$$Y = 2.84+0.017XK$$

On the basis of these analysis we summarized and recommended as follows:

The linear response to potassium agreed with the earlier reports by Igbokwe *el al.* (1982). We observed that increase in potassium above 40kg of K;0/hectare might not be necessary if N, P and K were to be applied simultaneously, to hybrid maize. The 40kg KO/ha would suffice when applied in combination with optimum rates of nitrogen and phosphorus. This study, therefore confirmed the "consumptive use" of potassium by maize genotypes.

The significant quadratic effects of nitrogen and phosphorus meant that the requirements for these elements by hybrid maize were met. The optimum nitrogen rate obtained in the study was approximately 143kgN/ha. Also, the optimum rate of phosphorus was 46kg P20.-, per hectare, and from this we inferred that phosphorus had a very high availability in the study and hence its subsequent utilization by the hybrid maize under the conditions of the experiment. We also inferred that the top dressing method of application probably reduced the unfavourable reactions of phosphorus with aluminium and iron both of which were

predominant in oxisols. Therefore, to apply the optimum rates of 142.5kgN/ha, 46kgP205/ha, using ammonium sulphate, single superphosphate, and muriate of potash as original sources ofN, P, and K. respectively, the hybrid maize grower would need 1000kg of NPK (15:3:4) fertilizer. This recommendation suggested that the use of the commonly available 15:15:15. NPK fertilizer in Nigeria was uneconomical since P05 and K:0 were supplied in excess of the optimum need of hybrid maize. We therefore, concluded that as long as the application method was such that minimized unfavourable soil reaction and nutrient losses, a mixture of **143kgN/ha, 46kgP20s and 40kgK20/ha would give a maximum yield response of hybrid** maize in the derived savanna zone of Southeastern Nigeria (Uguru and Obi. 1990).

Adaptation and Stability Estimates of Five Open-Pollinated Varieties of Maize *(Zea mays* L.) in Relation to Time of Planting in Southeastern Nigeria

Five open-pollinated varieties of maize: namely; **FARZ-7, FARZ-**23. **FARZ-34, DMR-EY** and **TZSR-W** were planted simultaneously a;
Nsukka and Igbarian locations on March 30, 1985 and continued at weekly intervals until May 18, 1985. This gave rise to a *series* of eigh' *similar experiments* in each location. Nsukka belongs to the deriveii savanna ecological zone and lies between 6''52'N, 7''24'E, with altitude of 447m. Igbarian is also. of the derived savanna ecological zone and lie between 6''23'N, 6°5'E, with an altitude of approximately 31m. The analysis-of variance was done to estimate the error variances of the characters for each date of planting in the two locations. This analysis made it possible for the Bartlett's tests of homogeneity of error variances to be performed as described by Snedecor and Cochran (1980).

A combined analysis of variance was done for each character for each location. A significant variety x time of planting interaction effect in the combined analysis of variance for a character within a location permitted stability analysis of the varieties on the location to be performed. A mathematical model according to Eberhart and Russ. (1966) was used, and stated as follow

$Y_{ij} = \mu = \square_i Ij + \delta_{ij,}$ where

Y_{ij} = mean of the i^{th} variety j^{th} environment (time of planting) μ. = mean of all varieties over all time of planting, pi = regression coefficient of the i^{11} variety on the environmental index, which measures the response of the variety to varying environments (time of planting), I, = the environmental index, which is defined as the deviation of the mean of all varieties at a given environment (time of planting) from the overall mean and is defined as

$$\sum_i \left(Y_{ij} / V \right) - \sum_i \sum_i \left(Y_{ij} / V_i \right) \text{ with } \square I_i = 0, \text{ where}$$

"V" is the number of varieties and "t" is the number of times of planting or environment; δ_{ij} is the deviation from regression of the i^{th} variety at j^{th}

environment or time of planting.

Also, in Eberhart and Russel's model, the regression coefficient "b" is the estimate of the parameter of response and $\overline{S_d^2}$ is the estimate of the parameter of stability. For a given value of the independent (explanatory) variable, the value for the dependent (response) variable may be estimated using a regression equation provided that $\overline{S_d^2}$ is equal to zero, that is, not significantly different from zero. According to Eberhart and Russel (1966), if $\overline{S_d^2} = 0$, a high value of "b" would mean more change in "y" for a unit change in the environmental index (Ij), that is, the variety is more responsive. Such a variety may be recommended for only highly favourable environments, say, under high fertility conditions. A relatively low value of "b", say, around b = 1, would mean less responsiveness to environmental change, and therefore more adaptive. If, however, "b" is negative, the variety may be grown only on poor environments. If *s* $\overline{S_d^2}$ is non-significant from zero. the performance of the variety for a given environment may be predicted. Accordingly, a variety whose performance can be predicted, that is, $\overline{S_d^2} = 0$, is said to be stable. On the other hand, if $\overline{S_d^2}$, is significantly different from zero, the linear prediction of the performance of the variety does not hold.

Stability parameters were estimated using the characters having significant variety x time of planting (V x T), interactions at both Nsukka and Igbariam locations. From the results of these analyses we' summarized and concluded as follows:

Date of planting strongly influenced the final expression of the characteristics of the five maize varieties used in the study. Some varieties showed predictable performance for such agronomic characters as days to 50% silking, total leaf area, field (ear) weight and grain yield. FARZ-7 was the most responsive to date of planting as suggested by a high and significant regression coefficient (b = 1.80) for grain yield. The most impredicatable variety was TZSR-W whereas DMREY was adapted to low yielding environment (b = 0.78). It v.nnid not he sufficient to rely on genotype x environment (G x E), analysis based on incomplete predictable environments to estimate adaptability and stability of maize variety/or release (Ndukauba and Obi, 1998).

Rapid Method of Estimating Total Maize *(Zea mays* L.) Plant Leaf Area as Affected by Genotype and Fertilizer Rates

Genotype affected the leaf area factor, the leaf number with the largest leaf area and the number of leaves available for measurements per plant. On the other hand. nitrogen fertilizer affected significantly only the leaf area factor and the number of leaves per plant. The procedure for estimating the leaf area factor for maize has been established by Obi and Imonide (1991).

The results of the correlation coefficients showed that the ***mean leaf number*** with the largest leaf area for the composite variety. FARZ-7 was 7, which was associated with the highest correlation coefficients of 0.91, 0.88 and 0.926 in replications I. II and III, respectively. Similarly, the hybrid, 8341-6 had its highest correlation coefficients of 0.92 and 0.907 with leaf number 6 in replications I and III and 0.89 in replication II for leaf number 5. From the correlation coefficients, it was apparent that even if the largest leaf number for the open pollinated variety FARZ-7

was 3, 6 or 7 the estimated total leaf area would be the same. Similarly, for the hybrid, 8341-6, leaf area factor estimated with leaf number 4, 5 or 6 would not differ. These results were consistent with those reported by Fraucis *et al.* (1969). The study revealed a ***second order interaction*** of nitrogen x phosphorus x variety (N x P x K), which was interpreted by using a geometric approach (Winer, 1971) as summarized in Fig. 1. The mean number of leaves per plant differed significantly between the two varieties studied at all combinations of nitrogen and phosphorus. The hybrid variety consistently had fewer mean numbers of leaves per plant than the open-pollinated variety at all combinations of nitrogen and phosphorus. For the hybrid variety the lowest rate of nitrogen (50kg/ha) at both levels of phosphorus did not differ significantly in the mean number of leaves per plant.

There was a significant increase in the number of leaves at l00kgN/ha with both levels of P. with the higher P level producing greater number of leaves/plant. At 150kgN/ha, there was a decrease in the number of leaves obtained with both levels of P. However, the higher level of P(60kg $P_2 0_5$/ha) sustained fewer number of leaves per plant (Fig. la).

With the open-pollinated variety (FARZ-7), the lowest level of nitrogen (50kgN/ha) at both levels of P significantly differed (P = 0.05), in their mean number of leaves per plant. Fewer numbers of leaves per plant were obtained with 50kgN than with the other combinations of nitrogen and phosphorus, except at l00kgN/ha and 60kgP/ha. Both I00kgN/ha and 150kgN/ha at 30kgP/ha had the same number of leaves/plant at both levels of phosphorus (Fig.lb).

Also. with 50kgN/ha and l00kgN/ha there were no differences in the mean number of leaves per plant with either levels of phosphorus. Although, an increase was observed with the higher level of phosphorus reducing the number of leaves per plant available for measurements, which was not significant (Fig. lc).

The implications of these results (Figs. la, b and c), *were that the hybrid was more responsive to* fertilizer *nitrogen -phosphorus balance than the open-pollinated variety'.* This phenomenon was consistent with the varieties throughout the parameters estimated in the study.

Development of University of Nigeria, Nsukka Popcorn (UNN Popcorn)

Three BCi and BCiSi genotypes, namely;
"AMI-ACHA " x ("AMI-ACHA " .v UNNPOP-White) BCi, *"AMI-ACHA" x ("AMI-ACHA" x IFE-White)* BCi and *"AMI-ACHA" x ("AMI-ACHA" x IFE-Yellow)* BCi;
"AMI-ACHA" x (AMI-ACHA" x UNNPOP-White) BCiSi, *"AMI-ACHA " X (AMI-ACHA " x IFE-White)* BCiS, and *"AMI-ACHA" x ("AMI-ACHA" x IFE-Yellow)* BCiSi were produced and with their parents namely; *"AMI-ACHA", UNN POP-White, IFE-White and IFE-Yellow,* were evaluated during the conversion of flint *"AMI-ACHA"* maize to popcorn.

The results showed non-significant differences among the genotypes in days to 50% tasselling, plant and ear heights. However, significant differences (p = 0.05), were observed between *IFE-white* and *UNNPOP-white,* but not between *IFE-white* and *IFE-yellow* BCi genotypes in days to 50% silking.

The BCiSi genotypes differed significantly (p = 0.05), from the parents in popping volume. The *"AMI-ACHA"* x *("AMI-ACHA"* x *UNNPOP-White)* BCiSi, *"AMI-ACHA"* x *("AMI-ACHA"* x *IFE-Yellow)* BCiSi and *"AMI-ACHA"* x *("AMI-ACHA"* x *IFE-White)* BCiS, genotypes had popping volumes of approximately 9, S and 4, respectively, which differed significantly (p = 0.05) among themselves and from their parents, that is *"AMI-ACHA", UNNPOP-white, IFE-yellow* and *IFE-white* genotypes, which had popping volumes of approximately 1, 4, 3 and 3, respectively.

Number of Genes Controlling Popping Volume or Expansion

The results presented in Table 10 show estimates of the number of genes controlling popping expansion/volume in the three crosses involving, *"AMI-ACHA"* and the three parental popcorns. The cross between *"AMI-ACHA"* and *IFE-White* had the largest number of 37 genes controlling popping expansion in IFE-White, followed by *"AMI-ACHA"* x *UNNPOP-White* with 35 genes controlling popping expansion in *UNNPOP-White.* The least number was from the *"AMI-ACHA"* x *IFE-Yellow* with 5 genes controlling popping volume. The new popcorn (Fig. 2) is named *UNNPOP-AA* (Obi *et al.*, 1995).

Fig. 2: Popping Expansion of Parental iTopi. and BCiSi Genotypes (Bottom), During Conversion of Flint *"AM1-ACHA"* Maize to Popcorn

Diallel Analysis Using Varieties and Breeding Lines

We started work on diallel analysis using maize varieties and rice breeding lines. The purpose of these studies is the possibility of developing varietal hybrids of these crops that will yield higher and with better qualities of carbohydrate, protein and oil. Earlier, we completed the study on the distribution of protein, lysine and oil contents in 100 genotypes of maize (Onwubiko and Obi, 2001).

Development of High Quality Green Maize Varieties Under Acid Soil Conditions of Southeastern Nigeria

\Ve have been able to develop high quality green mai/e suitable for green maize production in South-eastern Nigeria. After *the first selection cycle* in a phenotypic recurrent selection programme involving 113 maize genotypes we were able to develop early (Fig. 3) and late (Fig. 4) maturing high quality sweet maize populations. The results of organoleptic evaluation showed that approximate!} 57% *of* the genotypes were of very good taste, 51% were slightly hard. while 67% •••ere slightly chaffy. However, 74 genotypes, representing approximately 84% of the genotypes were preferred because they had combined attributes of good taste, moderate hardiness and chaff ness Okporie and Obi, 2005).

Fig. 3: Developed Early Maturing, Maturing, High Quality Sweet Maize

Fig. 4: Developed Late High Quality Sweet Maize

Physiological Mechanisms of Disease Resistance in Maize *(Zea Mays* L.) Phytoalexin Production in Plants

On completion of my Masters degree programme in the Department of Agronomy of the University of Illinois, Urbana-Champaign, I was admitted to read Plant Breeding and Genetics in the Department of Plant Pathology in the same University. At this period the focus was on the physiological mechanisms of disease resistance in plants involving -30-

phytoalexin production in plants. Phyloalexin was defined by Muller (1958 and 1961) as "antibiotics", which were produced as a result of the interaction of two different metabolic systems - *the host and the parasite,* which inhibited the growth of micro-organisms pathogenic to plants. New and improved techniques in biology and biochemistry have aided and facilitated more detailed studies giving better insight into the nature and mechanism of plants' defense against pathogenic attach. Consequently, biochemical approaches and techniques are used for obtaining a better knowledge of the physiology of disease resistance in plants.

Available information on ph\toalexin formation and function indicated that Mliller's interpretation and definition of phytoalexin concept was restrictive and, therefore needed redefinition. Hence, Kuc (1972), redefined phytoalexins to embrace all chemical compounds contributing to disease resistance, whether formed in response to injury, physical or chemical stimuli, the presence of agents or the products of such agents. In line with the idea of Kuc. a variety of heavy metals salts (Rathwell and Rendall, 1971) and Wood (1967). fungal extracts or culture filtrates (Cruichshank and Perrin. 1965). toxins (Goodman *et al.*, 1967) and even air pollutants (How ell. 1970). had been shown to stimulate phytoalexin production in a variety of cereal and vegetable crops.

In corn *(Zea mays* L.) several disease resistance expressions to *Helminthosporium tiircicum* Pass. have been recognized. These include polygenic and monogenic chlorotic-lesions and chlorotic-fleck. In plants having the gene ***Ht*** and infected with *H. turcium,* phytoalexin or phytoalexin-like compounds have been detected using the drop-diffusate or lesion extract techniques (Lim *el al.,* 1970).

Polygenic resistance in maize *(Zea mays* L.) is quantitative (lesion number) and disease reaction of the host, ranges from zero to total plant infection. In open-pollinated varieties, the polygenic type of disease resistance is quite common whereas the monogenic type is scarce and the chlorottic-fleck type is very rare.

Monogenic resistance in corn conditioned by the ///-gene is a qualitative phenomenon (lesion type), and is characterized by chlorotic-lesions, delayed necrosis, and inhibited fungus sporulation. The 7/f-gene has been successful in preventing yield loss in commercial corn

production in areas, especially in the United States of America, where the fungus is endemic. Also, it could be said that the *Ht-gwe* is a limiting factor for this fungus to reach epiphytotic proportions when other factors are favourable.

A combination of monogenic and polygenic resistance in corn lines, in commercial corn production, is effective in controlling the fungus and ensuring better yield (Hooker and Kirn, 1973). Hilu and Hooker (1964) and (1965), Ullstrup (1970) and others have compared disease reaction and yield of single-cross monogenic and polygenic corn lines. Polygenic types of disease resistance are generally believed to have the advantage of buffering resistance breakdown upon the emergence of a new race or biotype of the pathogen.

Histological studies by Jennings and Ullstrup (1957). Hilu and Hooker (1964 and 1965) and Hooker (1961) revealed that fungus *(H. turcium)* penetration of the corn leaf in the susceptible and resistant genotypes - monogenic, polygenic and chlorotic-fleck was identical. However, differences were observed after the fungus had entered the xylem in the monogenic and polygenic types. The chlorotic-fleck type of disease resistance, observed in B1138T sel from South Africa, was typified by the development of necrotic centres and failure of lesions to enlarge. Also, the fungus failed to penetrate the xylem. Hilu and Hooker (1964) showed that hyphal growth was more inhibited in the monogenic than in the polygenic resistant lines. Jennings and Ullstrup (1957), observed a wilt-type reaction in the lesions caused by the fungus on polygenic corn lines. They, therefore, theorized that the phenomenon was due to blockage of the xylem vessels by fungal hyphae. Hilu and Hooker (1965) believed that differences observed between the monogenic and polygenic disease reaction types were mainly due to the ability of the fungus to spread into the necrotic collenchyma of the polygenic, but not of the monogenic resistant corn lines.

The nature or physiology of disease resistance in the polygenic, other sources of chlorotic-lesion (types without the *Ht-gene),* and chlorotic-fleck types of disease resistance is now known.