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YIELD, THE ULTIMATE IN CROP IMPROVEMENT.

By

PROFESSOR I.O. OBISESAN
Professor of Plant Science

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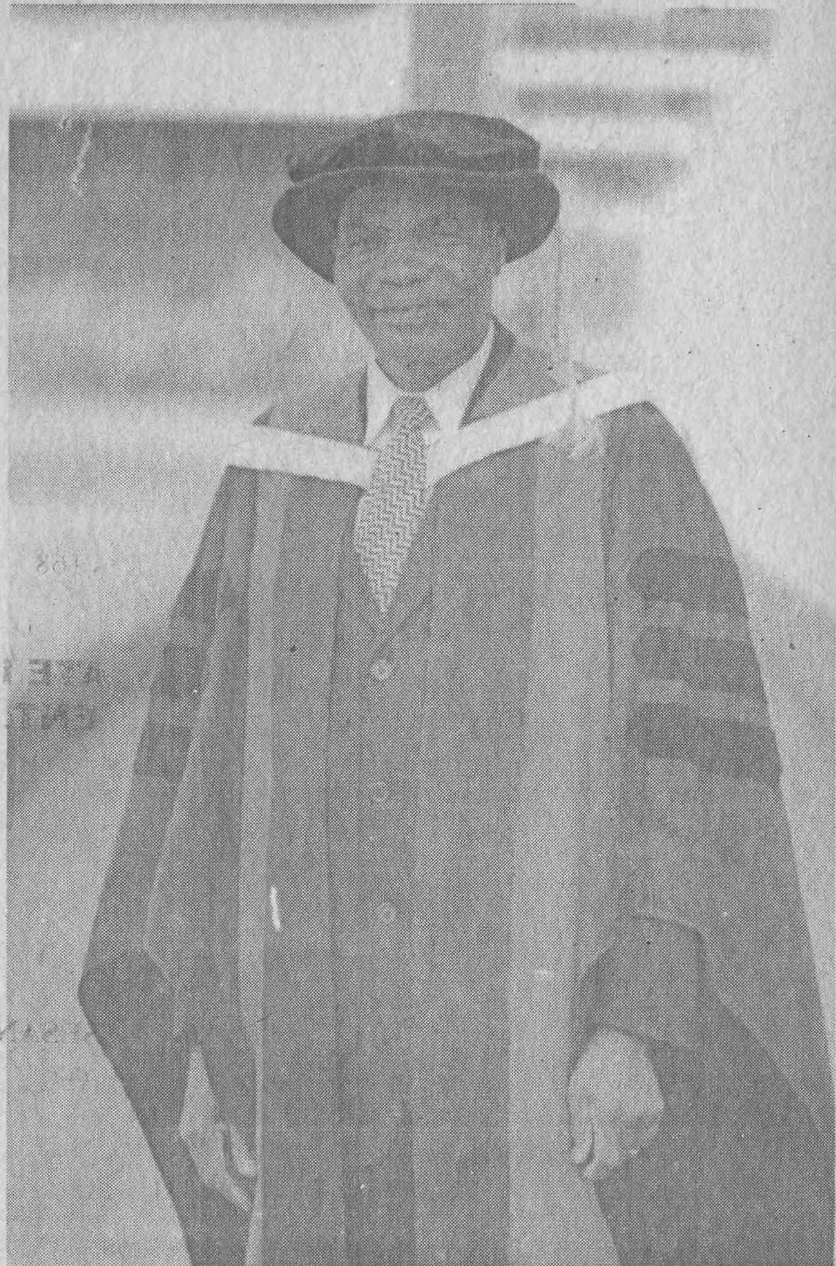

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Introduction

This is the second inaugural lecture in the area of plant breeding in the department of Plant Science and it is being delivered by the first Ph.D. candidate ever produced by the Department of Plant science.

I was admitted into the B.Sc. Honours Agriculture Degree Programme in the Faculty of Agriculture during 1970/71 session. At that time, the department in which an undergraduate will pass out is not known until the end of the second session when placement into departments was usually done, based on academic performance and choice of the student. I had two options: Plant Science or Soil Science. Dr J.D. Franckowiak aroused my interest in the area of Genetics and Plant Breeding. Professor E. O. Olutunla, formerly Tunde Fatunla, nurtured me into maturity in this specialist area of plant science.

My developmental years as a young plant breeder were spent at the Nigerian Institute for Oil Palm Research (NIFOR) near Benin City. Thereafter I assumed duties as Lecturer I in the Department of Plant Science of this University. In this lecture I shall explore the concept of yield and crop improvement, giving a modest account of my contribution to yield improvement as applicable to the oil palm (*Elaeis guineensis*, Jacquin), a permanent crop and cowpea (*Vigna unguiculata* L. Walp).an annual crop.

Yield

Yield represents a final product from physiological and developmental processes which occur from time of sowing to plant maturity .It is a product of the genetic constitution of the crop and its environment and it is the result of all production efforts on the farm.

In crop production it is measured in terms of the quantity of a desired crop per unit area. A typical crop consists of an underground part (the root) and an aerial part (the shoot).The shoot ultimately gives rise to stem, buds, leaves and reproductive structures. Each of these parts produces end products that are of interest to researchers, industrialists and farmers. Thus, reference is often made to tuber yield in cassava *(Manihot utilisima)* and yams (*Dioscorea spp);* grain yield in cowpea and maize (*Zea mays*); fruit yield in tomato (*Lycopersicon esculenta*) and mangoes (*Mangifera indica);*bunch yield in oil palm (*Elaeis guineensis*) and bananas/plantains(*Musa* spp.); oil yield in groundnut (*Arachis hypogeae*);leaf yield in leaf vegetables like "Tete" Amaranthus

(*Amatanthus* spp.) and fluted pumpkin (*Telfaria occidentalis*) called " úgu" in Igbo language. The larger the volume of yield, the happier the farmer and the better the quality of yield, the merrier the house wife and other ultimate end users.

From a mechanistic point of view, yield can be considered in terms of its components (Fatunla ,1973; Hartley,1977). Current experience suggests that yield improvement through the yield component approach could be augmented, using other approaches in producing varieties with significant yield differences. According to Wallace and Masaya (1988) the efficiency of breeding for higher yield can be raised by applying yield system analysis (YSA). Wallace and Yan (1998) reported nine outputs from the yield system of a typical crop cultivar that are measured by the yield system analysis procedure which included three major (penultimate) components and five derived/sub components(Table 1)

Table 1: The nine[1] outputs from the yield system of a cultivar that are measured by the yield system analysis procedure.

Output	Interpretation
Four direct measurement within each yield trial	
1. Days to flowering	Time used to develop to flowering
2. Days to harvest maturity	Time used to develop to harvest maturity
3. Aerial biomass	The net accumulated photosynthate
4. Yield	The economically valuable system output
Five calculations from the four direct measurements	
5. Days to seed fill	Time used for actual accumulation
6. Yield day^{-1} to maturity	Efficiency of yield accumulation
7. Yield day^{-1} to seed fill	Efficiency of yield accumulation
8. Biomass day^{-1} of plant growth	Efficiency of photosynthesis
9. Harvest index	Endpoint efficiency of partitioning to yield

[1] Traits 3,9 and 2 are the three major (penultimate) components of the process of accumulating the crop yield, and traits 1,5,6,7 and 8 are subcomponents ,i.e. they are the antepenultimate components of the yield system.

Source: Wallace and Yan, 1998

Crop Improvement

Crop improvement is the science and art of manipulating plant parts genetically, may be the roots, stems, leaves, flowers, seed, fruits, sap (latex) or gel as in *Aloe vera* for enhanced yield. This task involves the

understanding of genetics and application of same to bring about crop improvement. **Crop Improvement** which is synonymous with **Plant Breeding** is the science and art of changing and improving the heredity in plants (Phoelman and Sleeper, 1996). The Science of Genetics and the discipline of Plant Breeding have emerged only in the past 200 years but plants have been selected and bred from pre-historic times (Murray, 1993). As man's knowledge about plants increased, he was able to select more intelligently. With the discovery of sex in plants, hybridization was added to his breeding techniques .Although hybridization was practiced before the time of Mendelism, its significance in inheritance was not clearly understood until Mendel's experiments came to light and laid the basis for an understanding of mechanism of heredity in 1886 (Persley, 1992) .

As breeders knowledge of genetics and related plant science progressed, plant breeding became less of an art and more of a science. The plant breeder of today needs a proper grounding in genetics, particularly in the areas of quantitative and molecular genetics. No longer was it necessary for the breeder to rely completely on his skill in finding chance variations with which to establish variations. It is now possible to plan and create new types more or less at will. His scientific knowledge gave him the background to manipulate and direct inheritance of desirable characters in plants. Modern plant breeding is based on a thorough understanding and the use of genetic principles to produce better plants to meet consumer demands. The plant breeder harnesses knowledge in these areas of science to bring about crop improvement – botany , genetics and cytogenetics including molecular, quantitative and biometrical genetics; plant physiology, plant pathology, plant entomology ,plant biochemistry, agronomy of crops and statistics and biometry. Today, biotechnology has become available as a promising additional tool to aid plant breeding activities.

Reproductive/Breeding systems in Crops

Crops improved by plant breeders fall into 3 major categories- self pollinated crops (autogamous species) cross pollinated (allogamous species) and asexually propagated crops. The breeding methods depend on the reproductive system of the crop (Table 3).

a. Self pollinated crops:

Populations of self pollinated crops are little affected by inbreeding depression and they tend to become highly homozygous with inbreeding .The ultimate goal is to release pure lines of the different crops that operate this breeding system. Popular breeding methods for improvement of autogamous species include *Introduction:*(transportation of a desired plant or plant part from one geographical location to another). *Selection*: one of the oldest breeding methods. It is a process, natural or artificial, by which individual plants or group of plants are sorted out from mixed populations e.g. mass and pure line selection. *Hybridization:* Two varieties are crossed and the segregating populations handled by bulk, pedigree and single seed descent or backcross methods of breeding. The backcross method is particularly suited for transferring specific genes to a good variety which is deficient in one or a few desirable characters. Some examples of self pollinated crops include rice, tomato, cowpea, groundnut, okra and soybean.

Table 2 : Reproductive Systems and Breeding Methods in Crops

Features	Selfers	Crossers	Asexually propagated
Example of crops	Rice, wheat, tomato, cowpea, soybean, okra, groundnut etc.	Maize, pawpaw, cacao, avocado, coffee, many tree and horticultural crops. They are open pollinated varieties.	Onion, ginger, pine apple, sugar cane, sweet potato, irish potato, cassava, yams, plantain, banana, other crops propagated by root, stem, leaf or bud cuttings.
Breeding Methods	Introduction, Selection- Pure line Hybridization- Pedigree, Single seed, Early generation testing, Bulk population, Backcross breeding, Mutation breeding, Biotechnology- regeneration and transformation	Introduction, Selection-Mass selection Hybridization- Recurrent selection Biotechnology-tissue culture, regeneration and transformation.	Introduction, Selection-Clonal selection, Mutation breeding, Polyploidy breeding Biotechnology- tissue culture, regeneration and transformation
Effect of inbreeding	None- it is the normal way of reproduction	Deleterios.Effect of inbreeding depression manifest. Heterosis expressed- (F1 generation)	None-majority incapable of sexual reproduction.
Population/variety characteristics	Pure lines. Homozygote varieties. Special cases of multiline varieties	Heterozygote varieties e.g. Hybrids (single cross, double cross, three way cross, variety), composites, synthetic varieties.	A particular cultivar/cultigen is fixed irrespective of its degree of heterozygosity.

b. Cross Pollinated crops:

Population of cross pollinated crops is generally heterozygous and they are usually adversely affected by inbreeding. Unlike in autogamous species where the desirable varieties are pure lines, the varieties usually produced in allogamous species are not pure lines but heterozygote varieties like hybrids (single cross, double cross, three way cross, variety hybrids) composites, synthetic varieties. These varieties are developed using breeding methods like mass selection, backcross breeding, hybridization of inbred lines or other suitable materials for hybrid varieties, recurrent selection (simple, reciprocal) and development of synthetic varieties from selected genotypes. In recurrent selection, desirable genotypes are selected and these genotypes or their selfed progenies are intercrossed in all combinations to produce populations for reselection. Synthetic varieties are advanced generation hybrids and they are made up of genotypes which have previously been tested for their ability to produce superior progenies when crossed in all combinations (Allard,1960). Varieties of cross pollinated crops are generally more genetically variable than varieties of autogamous species. Examples of allogamous species include maize, oil palm. (both are monoecious species): date palm (*Phoenix dactylifera*), pawpaw (*Carica papaya*) and avocado pear (*Persea americana*) all three are dioecious crops having separate male and female plants.

c. Asexually Propagated Crops

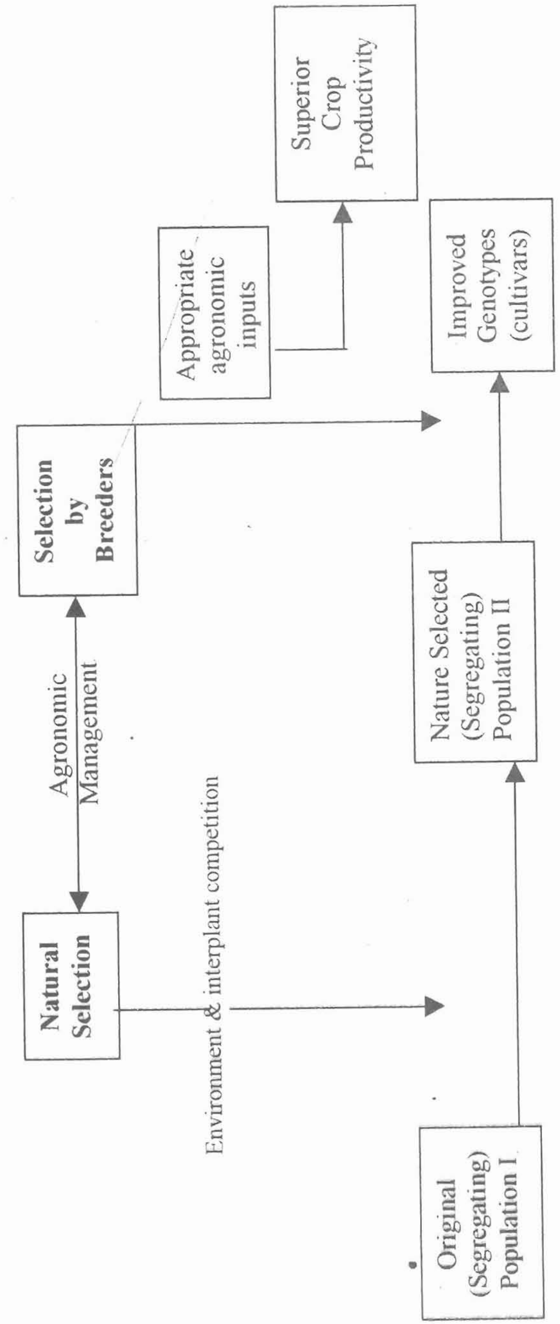
Asexual propagation is used in species that are seedless, produce seeds very poorly or that produce seeds only on special conditions. The best known means of asexual or vegetative propagation are by corms (cocoyam- *Colocasia esculentum*), bulbs (onion- *Annnum capa*), rhizomes (ginger- *Zingiber officinale*), stem tubers (yams, irish potato); root tubers (cassava, sweet potato); root and leaf cuttings, suckers, slips, stolons or other vegetative organs. Asexually propagated crops are highly heterozygous and they segregate widely upon sexual reproduction. Clones are easily obtained from asexually propagated crops since the character is fixed over generations .A clone is a community of plants that have originated from a single plant or plant's part and had been multiplied and maintained over generations by vegetative means. Allard (1960) defined a clone as a group of organisms descended by mitosis from a common ancestor. Asexual reproduction leads to perpetuation of the same genotype with great precision. An indefinitely large number of genetically identical individuals can be obtained irrespective of the degree of heterozygosity of the genotype. Consequently the breeder can take advantage of outstanding individuals occurring at any stage in a breeding programme since any desirable genetic combination is fixed immediately and propagated indefinitely.

The Art of Plant Breeding

Selection is an intrinsic part of plant breeding which is as old as plant breeding itself. With thousands of plants or strains to choose from, the plant breeder's reasons for making a particular choice should always be clear. Usually a plant breeder has in his mind a distinct mental picture of the type of plants he wants to create- an ideotype. In making the choice, the breeder exercises skill and judgement gained from experience about the plant with which he is working. This is the art of plant breeding.

The clarity and precision with which he can evaluate a strain may be enhanced if his visual observations are supplemented with accurate information about the performance of the strain which has been obtained through various testing techniques. For these reasons, a large part, of the breeders work is devoted to testing procedures designed to help him evaluate the breeding materials. The plant breeder adopts various strategies to carry out selection of desirable plants (Fig 1). To improve the genetic potential for crop yield, breeders should select within target environment for high genetic improvement.

Fig 1: Strategies for Selection



Source: Wallace and Yan. 1998

The concept of a 'Trait': important traits or characters in plants

The traits/characters which plant breeders improve in plants are as diverse as the many crops they attempt to improve. A trait is an observable or measurable character. When such a trait can be adequately described by mere observation or counting ,such a trait is **qualitative** and its expression is usually controlled by one or a few **oligogenes**. The environment has little or no effect on the expression of such traits and they are always highly heritable. However, when precise several measurements become necessary before a trait can be meaningfully and adequately described, it is referred to as a metric or **quantitative** trait. Many of the economic traits in crops are quantitative **(polygenic)** in nature and their expression is modified to a large extent by the environment.

The phenotype

The outward appearance of a trait describes the phenotype .The phenotypic expression of a character such as yield can be considered as the sum of a gene effect and a deviation attributable to environment and interaction between the genotype and the environment if genotypes are randomly distributed relative to variations in the environment. Phenotypic variance is a sum of the variance of genetic effects and variance of environmental effects i.e.

$\sigma^2 P = \sigma^2 G + \sigma^2 E$ (Comstock and Robinson, 1948)

Where
$\sigma^2 P$ = Total phenotypic variance
$\sigma^2 G$ = Total genetic variance
$\sigma^2 E$ = Total environmental variance

And total genetic variance is partitioned into

$\sigma^2 G = \sigma^2 A + \sigma^2 D + \sigma^2 I$
Where
$\sigma^2 A$ = Additive genetic variance
$\sigma^2 D$ = Dominance genetic variance } Non additive genetic variance
$\sigma^2 I$ = Epistasis (interaction) genetic variance }

Additive genetic variance is that portion of total genetic variance resulting from average gene effects and reflects the resemblance between parents and offspring. It is therefore the chief determinant of the observable genetic properties of populations and the response of population to selection (Falconer,1960).The estimation of additive and non-additive genetic variances requires the use of appropriate mating designs viz- Diallele analysis, North Carolina designs I (nested); design II(cross classification) and design III (backcross); Generation mean analysis and Scaling test (Sign and Chaudhary,1977; Comstock, Robinson and Harvey,1959;Mater and Jinks, 1977).

Estimate of genetic variances can be of value in any of the three stages of a plant breeding programme viz:

(a) Assembly of creation of a gene pool of variable germplasm
(b) Selection of superior individuals from the pool and
(c) Utilization of selected individuals to create a superior variety (Dudley and Moll,1969)

These estimates are of prime importance in the generation of genetic parameters like heritability and gains from selection experiments.

Steps in a breeding programme

1. Conservation and assemblage of a large germplasm of the target crop.
2. Evaluation and characterization of the germplasm.
3. Determination of association among plant characteristics in the gene pool (r_g, r_{ph}).
4. Basic genetic studies on the inheritance of traits in the populations.
5. Making meaningful crosses and using appropriate mating designs to study gene action.
6. Choice of appropriate breeding methodology and selection methods.
7. Introgression of exotic genomes when necessary.

MY NIFOR EXPERIENCE

The Oil palm

Majority of the attempts made by researchers to improve yield in "the oil palm", understandably, is concentrated on the West African oil palm (*Elaeis guineensis,* Jacquin). Introgression of exotic germplasm like Deli palms from South East Asia, Pobe dumpies from Republic of Benin and

American oil palm (*Elaeis oleifera* (Kunth) Cortes) from Equatorial South America have been employed to improve the oil palm in terms of bunch yield, height attainable at maturity and quality of mesocarp palm oil. Whereas, *E. guineensis* has a single erect stem reaching to a height of 15-18m at adolescence, (Plate1), *E. oleifera* (Plate 2) has a procumbent stem and reduced height (Mennier, 1975). The slow stem height increment and better mesocarp oil attribute of *E. oleifera* have been used to improve and produce short growing palms with high mesocarp oil quality (Meunier. 1975, Arnaud and Rabechalt, 1972, Obasola *et al*., 1976). Similarly, the Deli and Pobe dumpies which have characteristic big bunches (Plate 3) have been used to improve 'the oil palm' for jombo size bunches (Obisesan and Parimoo, 1985).

Plate 1: *E. guineensis*

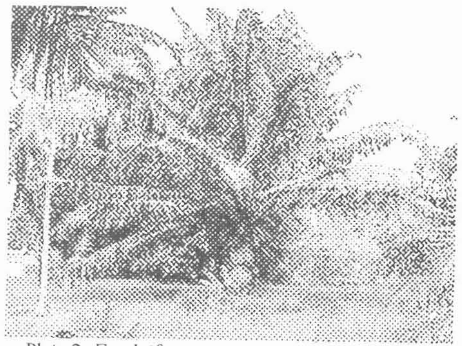


Plate 2: *E. oleifera*

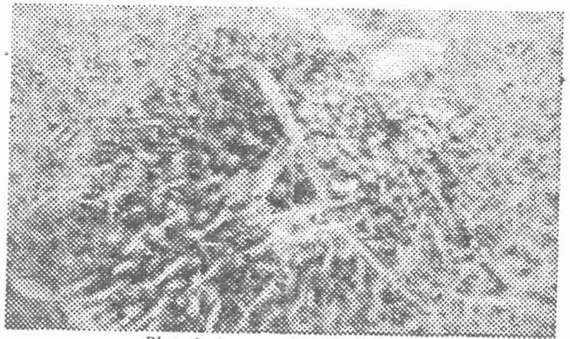


Plate 3: An extra-large bunch

The oil palm fruit is a sessile drupe with spherical to avoid or elongated shape. The approximate number of fruits on E. *guineensis* and *E. oleifera* bunches are 1,739 and 2,533 respectively and 2164 for the

hybrid (Obisesan, 1982). The cross section of a typical fruit reveals that the fruit is composed of a leathery exocarp, a fleshy mesocarp and a stony endocarp, consisting of the shell and the kernel (Plate 4). On the basis of variation in the shell thickness, *E. guineensis* is classified into three fruit forms viz the *dura* (homozygous for thick shell), the *pisifera* (homozygous for no shell) and the *tenera* (a monohybrid cross between *dura* and pisifera, heterozygous for thin shell(Plate 5). The West African oil palm exists in nature predominantly as the *dura* fruit form which constitutes over 95% of wild population. The *pisifera* fruit form occurs naturally at a low frequency of less than 1%. *Pisifera* palms are generally unproductive because they are female sterile. They are therefore used as male parents in *dura* x *pisifera* crosses to obtain *tenera* palms. Identification of *pisifera* palms at juvenile/seedling stage is difficult. We proposed a methodology embracing the use vegetative and physiological characters for early identification of *tenera* palms among segregating swarms (Parimoo *et al*., 1982).

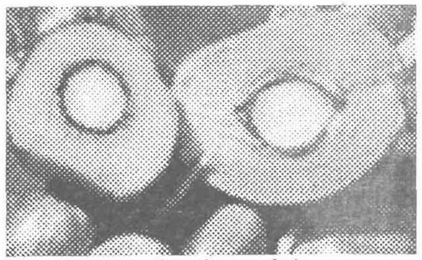


Plate 4: Cross-section of tenera fruits

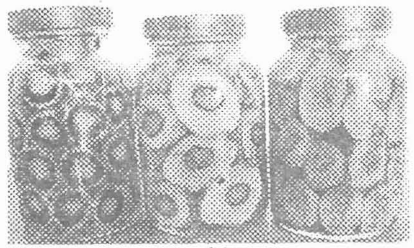


Plate 5: Cross-section of dura, tenera and pisifera fruits

The major yield parameters in the oil palm are fresh fruit bunch yield (FFB), mesocarp oil yield and kernel oil yield. Quantitative genetics studies have shown that FFB is determined largely by number of bunches produced per palm and mean bunch weight (Sparnaaij *et al*.,1963) and that stable FFB is usually sustained by a compensatory reaction between number of bunches (NB) and mean bunch weight (MBW). On a typical oil palm plantation,. NB decreased while MBW increased for the first 14 years of production (Obisesan and Fatunla, 1981) after which FFB stabilizes (plateaus) before eventual decline due to age and unreachable/unharvestable ripe bunches at the top of very tall palms. Sex ratio (the proportion of female to total number of inflorescences produced by the palm) is the third major determinant of FFB yield.

Mesocarp oil is the most important economic product of the oil palm. Mesocarp oil yields of *dura* and *tenera* palms differ significantly. It is higher in *tenera* than *dura* palms (Table 3).

Table 3: Oil yield component of NIFOR elite tenera compared with the improved and unimproved dura

Oil Yield Component	NIFOR Elite Tenera	Improved Dura	Unimproved Dura In the wild
Mean FFB	15-18 tonnes/ha./year	15-18 tonnes/ha./year	3 tonnes/ha./year
	60-70	65-75	
% Fruit/Bunch	80-85	30-60	50-75
% Mesocarp/Fruit	5-15	30-50	20-50
% Shell	5-13	7-20	30-65
% Kernel			7-20
Oil yield in Tonnes/ Hectare/Year	**4 – 5 tonnes**	**1.2 tonnes**	0. 5 tonnes
Kernel yield	1.64	2.70 tonnes	0.45 tonnes kernel yield
Kernel Oil	0.82 tonnes	1.35 tonnes	0.225 tonnes

Source: NIFOR, 1984 (adapted)

Obisesan (1990) documented the fact that the two primary determinants of mesocarp oil in *dura* and *tenera* palms are FFB and O/M (Tables 5 and 6). Oil palm plantations should therefore be properly managed so that palms may produce many fresh fruit bunches(FFB).

Table 4: Summary of direct (on diagonal), indirect (I), residual effects (E), D- and R^2- values of FFB, O/M, M/F and F/B on mesocarp oil yield in *dura* fruit forms.

	FFB	O/M	M/F	F/B	I	C	E	D	R^2
FFB	0.7840** (0.8322**)+	0.0623	-0.0547	0.0413	0.0489	0.8239	0.0003	0.6532	0.6942
O/M	0.1290	0.3790** (0.5035**)	-0.0121	0.0067	0.1236	0.5025	0.0027	0.1908	0.1379
M/F	-0.1244	-0.0133	0.3446 (0.1991)	-0.0079	-0.1456	0.2334	-0.0343	0.0686	0.1149
F/B	0.1853	0.0144	-0.0155	0.1749 (0.3591*)	0.1842	0.3591	0.0000	0.0628	0.0289

Table 5: Summary of direct (on diagonal), indirect (I), residual effects (E), D- and R^2 – values of FFB, O/M, M/F and F/B on mesocarp oil yield in *tenera* fruit forms.

	FFB	O/M	F/B	M/F	I	C	E	D	R^2
FFB	0.8007** (0.8537**)	0.0477	0.0190	0.0138	0.0850	0.8812	-0.0275	0.6836	0.7288
O/M	0.0934	0.408[illegible]** (0.53[illegible]7)	0.0203	0.0170	0.1307	0.5396	0.0001	0.2207	0.1963
F/B	0.0681	0.0370	0.2241 0.3002	0.0176	0.1227	0.3468	-0.0466	0.0673	0.0373
M/F	0.0674	0.0426	0.0398	0.1634 (0.0988)	0.1498	0.3132	-0.2144	0.0160	0.0253

R^2= coefficient of determination values obtained from stepwise multiple regression equation

+ = figures in parenthesis are correlation coefficients between the corresponding trait and oil yield

** * = significant at 0.01 and 0.05 levels of probability respectively.

Jackson (1976) showed that measurement of either the crop or the environment prior to harvest will establish an empirical relationship between yield and earlier measurements of the plant or the environment. Such information could be used for prediction purposes and will give ample opportunity for management for decision making and adjustment purposes. In the oil palm, yield performance in later years is determined by climatic events in the previous 2-3 years. Out of six climatic factors viz. annual rainfall (RA), sunshine hours (SH), relative humidity (RH), mean annual temperature (AT) mean number of dry days or rainless days (DD), and heat units (HU), only RA, SH and RH significantly influenced sex ratio, FFB, and mesocarp oil yield in oil palm (Obisesan and Fatunla ,1985 & 1987). Information on these climatic factors has served management and predictive purposes.

Heritability and repeatability estimates in the oil palm

While heritability is an estimate of proportion of the attributes of the parents that is transmitted to the offspring, repeatability of a trait gives an indication of gain in accuracy to be expected from multiple measurements of a trait on the same individual over time (Hansche and Brooks, 1964). Heritability and repeatability estimates of FFB and mesocarp oil yield components from several experiments have clearly demonstrated that selection interval could be reduced without any loss of precision. Thus evaluation for these traits could be done after 3 years of data collection (Obisesan and Fatunla, 1980, 1982 and Table 6).

Table 6: Effect of Repeatability estimates on time of evaluation for yield components in the Oil palm

Component	r (%)	Nrm	Afp
No. of Bunches	33	3-4	5-6
Mean Bunch Weight	8	4	6
Fresh Fruit Bunch	11	4	6
Sex Ratio	8	4	6
Mesocarp Oil	11	4	11*
Kernel Oil	87	1	8*

r (%) = repeatability estimate

Nrm = number of repeated measurements recommended

Afp = age of palm from planting when evaluation is recommended

* = data collection on mesocarp oil commenced at the fifth year of bearing

Application of this information to yield related breeding programmes in oil palm has substantially reduced the generation interval and recurrent selection cycles.

As much as height affects the economic life span of the oil palm, short palms have been bred for improved bunch yield and mesocarp oil quality (Obasola *et al.*, *1976*; Parimoo *et al.*, 1985).

MY OBAFEMI AWOLOWO UNIVERSITY EXPERIENCE

The Cowpea

The cowpea (*Vigna unguiculata* L. Walp) belongs to the family Fabaceae, sub family Faboidieae and tribe Phaseoleae (Cronquist, 1988). The genus contains about 170 species of herbaceous erect, semi-upright, prostrate-spreading and twining-climbing forms (Blackhurst and Miller, 1980). Cowpea is an important component of the food intake in Nigeria and in the less developed countries of the tropics. The nutritional value of cowpea lies in its high protein content of 20-25% and is double the protein values of most cereals (Dovle *et al* ..1984).Thus cowpea compliments cereals in diets of millions of people who cannot afford to produce sufficient animal protein (Sigh.1987).

In spite of the importance of cowpea to the livelihood of the people, and efforts made at both the National and International levels to improve cowpea production, its seed yield still remains relatively low in Nigeria. The following are some of my modest contributions towards the improvement of cowpea yield.

Germplasm Collection, Assemblage and Evaluation

A collection of cowpea germplasm is maintained in the Department of Plant Science. The germplasm is broadened from time to time as new additions are made from our breeding and collection activities. These lines (those already available) have been screened for resistance to brown blotch disease (*Colletotrichum truncatum*), virus diseases and economic insect pests. In one of our trials, sixty four lines of cowpea were screened for resistance to brown blotch disease in the greenhouse and on the field for four seasons. Five varieties, Crimson, Hope, TVx3236,

Tvu1896AG, and H144-1 were consistently resistant while Ife Brown, Ife Branching Peduncle Cowpea (BPC) and A44/2 were consistently susceptible over the four growing seasons (Table 7).

Table 7 Evaluation of some cowpea germplasm for resistance to disease and insect pest

Trait	No. of germplasm screened	No. Resistant/Immune	Reference
Cydia ptychora	82	7	Ofuya and Akingbohungbe, 1987.
Colletotrichum capsici	40	5	Obisesan *et al.*, 1988
CpMV	198	52	Ladipo, 1985

Source: Obisesan, 2003a

The brown blotch disease is a fungus disease first identified by Emechebe in 1981. It is an economic disease of cowpea which can bring a total crop failure when epiphytotic development of the disease occurs at the time of initiation of pod development. Out of 198 cowpea germplasm accessions screened during greenhouse inoculations with the cowpea and crololaria isolates of cowpea mosaic virus (CpMV), fifty two lines were immune (Ladipo, 1985). Ofuya and Akingbohungbe (1987) found promising levels of resistance to *C. ptychora* (Meyrick) (Lepidoptera: Tortricidae) in 7 varieties of cowpea during various replicated field trials at Ile-Ife. The development of resistant plant varieties remains the most promising and environmentally friendly method to control diseases and insect pests.

The present rate of development in different sectors of our economy is gradually eroding the rich plant genetic resources in our environment. Many minor and underutilized legumes are being endangered and are rapidly approaching the verge of extinction. Now is the time for concerted and aggressive moves to salvage threatened plant species from complete erosion from our forests and grass lands. Arising from this, one of my present postgraduate students, Mr. R.O. Akinwale is working on "Collection, conservation and characterization of some underutilized legumes of Southwestern Nigeria" for his M.Sc. degree. The collections have been conserved and they are being characterized.

Genetics of some economic traits in cowpea

A necessary prerequisite in the improvement of any trait is a proper understanding of the genetics of its inheritance, Not only will the understanding suggest the gene actions moderating their expression, it will also help in the choice of parents for specific crosses and the breeding methods to actualize maximum reward from the selection exercise.

(a) Brown Blotch Disease

The inheritance pattern of resistance to brown blotch was investigated by using crosses involving two resistant (Hope, Crimson) and two susceptible (Ife Brown and BPC) parents. The F1 data indicated that resistance was dominant over susceptibility. Segregation patterns in the F2 and backcross generations of all crosses showed that two dominant nuclear genes conditioned resistance to brown blotch disease.

(b) Virus Diseases

Cowpea crops are susceptible to more that 20 viral diseases (Hampton *et al.* 1997). Cowpea aphid-borne mosaic virus (CAMV), southern bean mosaic virus (SBMV) and cowpea mosaic virus (CpMV) are widely distributed in Nigeria (Ghant, 1959). Sources of resistance to cowpea mosaic virus were reported by Ladipo (1985). Sources of resistance to cowpea aphid-borne mosaic virus (Ladipo and Allen, 1979) and southern bean mosaic virus in cowpea have also been reported (Ladipo and Allen, 1996).

In our quest to develop improved cowpeas with resistance to virus diseases, we expatiated the genetics of inheritance to some of these virus diseases. My first graduate student, Mr. J.A. Arowolo researched on the topic " Inheritance of resistance to cowpea aphid-borne mosaic virus in cowpea (*Vigna unguiculata* (L.) Walp)" for his M.Sc. degree. During the study, it was demonstrated that resistance to the cowpea aphid-borne mosaic virus (CAMV) was simply inherited and conditioned by different recessive genes in pure lines TVu 22, TVu 612, TVu 1948 and A44/2 and also that resistance to the Southern Bean Mosaic Virus was also controlled by a single dominant gene (Arowolo and Obisesan , 1986). In two of our recent studies where each of seven lines of cowpea –Tvu 184, TVu 202, TVu 222, Tvu 346, TVu 697, Tvu 746 and Tvu 1029 which is resistant to cowpea mosaic virus (CpMV) was crossed to three susceptible varieties of cowpea – Ife Brown, IT86D-719 and IT86D-721 in order to evaluate the inheritance pattern of resistance to CpMV, it was observed that resistance was dominant to susceptibility and that the

resistant reaction was governed by either a single dominant gene or two dominant genes with epistatic interaction (Ladipo *et al.*, in press). Cowpea ideotypes with desirable agronomic characters like big seed size, white/brown coloured and rough testa and resistance to CpMV which are now at F_4 generation have been obtained from our concerted efforts and are being rapidly advanced to homozygosity in order to obtain their pure lines. A summary of the genetics of the inheritance of some important traits in cowpea is provided in Table 8.

Table 8 : Genetics of inheritance of some traits in cowpea

Trait	No. of crosses	Mode of inheritance	Reference
Brown Blotch	4	2 dominant genes governed resistance.	Obisesan,1990a
SBMV	3	1 dominant gene governed resistance.	Arowolo and Obisesan, 1986
CAMV	3	2 recessive genes governed resistance	Arowolo and Obisesan, 1986
CpMV	15	1 dominant gene governed resistance	Ladipo *et al.* In press
	5	2 epistatic genes governed resistance	Ladipo et al. In press
Peduncle type	4	1 recessive gene governed branched peduncle.	Obisesan and Mefor, 1986
Pod texture (Leathery vs. papery)	6	1 dominant gene /3 epistatic genes governed leathery texture	Obisesan,1990c
Pod resistance to seed beetle	6	Monogenic and incomplete dominance	Okpalefe,1982
Seed resistance to seed beetle	4	2 recessive genes and cytoplasmic factors	Rusoke and Fatunla, 1987
Optimum seed weight	4	4-5 genes	Obisesan,1990b

Yield Components

Graffius (1959, 1960) working on barley presented evidence to show that there are no genes for yield as such but only genes for yield components. The failure of yield components to be more consistently useful as indirect selection criteria for yield has been commonly attributed to low heritabilities, large genotype by environment interaction and to the phenomenon of component compensation(Adams, 1967; Erskine and Kan,1978; Tikka and Asawa,1978). The phenomenon of component compensation in legumes is thought to be due to developmental independences among sequential components of a complex trait such as yield. Eartley and Laing (1973) working on cowpea suggests that visual selection for high number of pods per plant in the field may be used as a preliminary selection criterion to reduce the number of plants which will be evaluated for yield. Ogunbodede (1981) identified number of seeds per pod, pod length, seed crowding index and 100 seed weight as the yield components of cowpea. In 1985, a study was conducted to elucidate the association among grain yield components in cowpea (Obisesan,1985). Associations between grain yield and eight quantitative characters were studied in 40 genotypes of cowpea over 3 growing seasons. Using a combination of multiple regression and path coefficient analyses, the three major components identified were number of pods per plant, 100 seed weight and number of seeds per pod. However the study also revealed that the subtle indirect effects of other morphological traits such as number of peduncles per plant, length of peduncles, number of main branches and vigour index should not be discountenanced.

This finding aroused my interest in the study of morphological and phelonogical traits in cowpea. Yield is now being analysed using different approaches. Two popular approaches are the yield system analysis (YSA) approach and the systematic modeling approach. Boote and Tollemar(1994 used a crop modeling approach to evaluate genetic traits for their potential to increase yield through enhanced photosynthesis, partitioning to seed, filling period duration and/or remobilization. They speculated that yield can be increased by extending the pod filling period if photosynthesis and pod fill are concurrently extended. Environment has a significant effect on this trait and Obisesan (1986) reported pod filling period was longer in the early(rainy) season than in the dry(late) season.

Morphological and Phenological Traits

Morphological traits are those characters of the plant that describe the plant in terms of its appearance and architecture. Morphological traits have been identified as equally important as the "primary" yield components in breaking yield barriers. In search for alternatives to yield

components as indirect selection criteria, breeders are becoming increasingly interested in the exploitation of growth habits like leaf type, peduncle lengths, branching patterns and plant height for increased yield (Ghedari and Adams, 1981; Adams, 1982, Erskine *et al.*, 1988, Fawole and Afolabi,1988).

Phenological traits are developmental traits and they are calendar based e.g. number of days to germination, days to first node formation, days to flower bud formation, number of days to flower formation, number of days to pod maturity (physiological or harvest), pod development period or seed fill duration.

Mr. B.J. Amujoyegbe was my first postgraduate student to investigate the influence of morphological and phenological traits on cowpea yield. In a study involving 32 varieties of cowpea, evaluated over two seasons, cowpea traits were grouped as seedling, maturity and yield components. Emergence traits showed positive direct effects on grain yield. Yield growth rate showed the most significant effect on grain yield with a direct effect of 0.900. Out of the twelve highest yielding varieties, 6 varieties: K-59, IAR-48W, IAR48, K-39, IT85F–958 and IT86D-1010 showed distinct superiority for yield. It was also evident from the study that in addition to conventional traits like number of pods per plant and 100 seed weight, seed growth rate, yield growth rate, biomass and biomass growth rate are alternate pathways through which cowpea achieved high grain yield (Amujoyegbe and Obisesan ,1997). Irrespective of the yielding capabilities of the 32 varieties (i.e. high >1000kg/ha or low yielding <1000kg/ha), all the growth traits (seed growth rate (SGR), seed yield/days of seed fill, yield growth rate (economic growth, YGR), seed yield/days to harvest maturity (DHM), biomass growth rate (BGR), biomass/DHM showed higher positive significant correlations with grain yield in both cowpea groups. However, the high yielders had greater YGR and BGR values than the low yielding varieties (Tables 9 and 10).

Table 9: Mean grain yield and biomass accumulation (kg/ha) of 32 varieties of cowpea evaluated in Ile-ife, Nigeria.

Varieties	SEED YIELD(Kg/ha)			BIOMASS(Kg/ha)		
	Early Season	Late Season	Across Season	Early Season	Late Season	Across Season
K-59	640.66	2479.06	1559.06	2211.13	4188.72	3198.91
IAR-48W	1292.96	1725.24	1509.05	3580.00	3015.65	3297.82
IT86D-1010	1588.01	1381.05	1484.52	4108.90	2933.35	3521.14
IAR-48	1179.43	1742.04	1460.73	2968.95	25000.00	2734.59
K-39	1384.62	1343.33	1364.00	2249.00	3466.76	3150.02
IT83F-958	1151.14	1366.04	1240.56	3077.83	3222.24	3150.02
H-113-4	1855.33	594.61	1225.07	2928.95	2080.00	2504.48
IT86D-880	1168.73	1024.16	1096.42	2653.33	19689.92	2811.14
OB89(5)	877.33	1273.05	1075.22	2824.52	2791.16	2807.86
IT87D-1629	1110.83	994.64	1052.73	2795.67	2804.45	2800.00
IT86D-721	769.53	1333.76	1051.67	2208.96	2782.25	2495.51
IT85D-3577	867.67	1190.79	1029.11	3248.92	2975.63	3112.26
K-28	1183.67	790.79	987.15	3311.16	1884.13	2597.81
OBV5	1223.67	688.41	956.03	2942.27	1902.23	2422.23
L-72	1097.13	811.52	954.33	3595.68	2629.95	31112.33
OB89(4)	889.53	1017.33	935.43	2913.40	2635.60	2774.52
OB89(1)	563.84	1204.75	884.26	2633.38	2862.27	2747.83
OB89XI	1000.26	751.77	875.93	3024.43	2031.14	2527.83
12AK	831.13	912.33	871.73	2539.55	1888.93	2214.27
IF83-1-4(A)11	777.96	940.33	859.18	2533.34	2408.93	2471.16
IFE BROWN	1011.86	695.24	853.64	2471.16	1901.32	2186.25
IT86D-715	1049.46	641.00	845.26	2966.73	2026.63	2496.63
IT87S-1463-B	1042.56	619.86	831.27	4111.18	2360.02	3235.57
L-80	1120.00	463.11	792.19	2884.46	1842.26	2863.37
IT87S-2246-4	884.33	631.06	757.64	3206.76	2262.26	2734.52
IAR11/48-2	1151.13	302.21	708.77	3237.82	1782.24	2510.00
IT87D-1134	705.25	663.42	684.32	2155.63	1904.42	2030.00
OB89(3)	645.42	559.76	602.58	2861.35	2328.92	2595.19
OB89(312)	593.67	407.17	500.41	2022.28	1191.10	1606.72
MAID-L	4.20	745.92	375.07	1995.63	1999.51	1997.52
IF83-144(A) 21	148.33	599.22	373.86	1560.00	1684.42	1622.26
OB89(2)	194.52	492.55	343.52	1442.26	1766.73	1604.04
MEAN	935.37	949.51	942.44	2851.98	2375.56	2613.78
LSD 5%	402.28	359.12	268.39	1209.50	685.48	728.23

Table 10: Mean values of some yield system output traits and some yield components in 32 varieties of cowpea across seasons.

Varieties	No. of pods (NPP)	Yield/day of seed fill (SGR) (g)	Yield /growth duration (YGR) (g)	Biomass/g rowth duration (BGR)	Harvest Index (HI)	100 seed wt.
K-59	32.83	39.91	17.07	35.16	24.17	9.67
IAR-48W	32.83	35.81	15.62	34.38	47.83	14.17
IT86D-1010	25.00	30.85	16.69	39.58	43.50	14.10
IAR-48	57.33	34.54	15.99	29.56	55.50	12.00
K-39	33.17	32.26	15.89	38.80	38.83	12.67
IT83F-958	55.17	34.70	18.70	34.78	39.33	9.00
H113-4	26.83	27.20	12.77	26.89	43.00	14.00
IT86D-880	22.00	28.81	12.87	32.88	42.67	12.92
OB89(5)	31.00	23.48	11.42	29.89	39.00	11.33
IT87D-1629	21.33	26.95	12.07	32.11	38.00	12.00
IT86D-721	23.33	26.02	12.13	29.02	41.17	12.00
IT85D-3577	27.56	26.16	11.73	35.45	33.67	11.08
K-28	32.17	22.99	10.97	28.28	38.82	12.83
OBV5	32.95	21.64	10.37	27.27	38.67	10.17
L-75	29.00	22.05	10.41	34.00	30.50	11.92
OB89(4)	25.83	24.09	10.91	31.26	35.50	10.17
OB89(1)	28.00	19.33	9.13	28.31	31.50	7.50
OB89XI	26.83	21.41	9.67	27.83	35.33	10.08
12AK	30.67	20.57	9.66	24.22	39.33	8.67
IF83-1-4(A) 11	33.50	21.67	8.79	25.40	36.50	8.67
IFE BROWN	33.67	23.78	9.68	24.91	39.17	11.83
IT86D-715	22.17	22.15	9.35	27.39	34.00	10.83
IT875-1463-B	31.00	16.80	8.44	32.97	26.67	12.50
L-80	34.67	20.24	6.62	31.21	26.50	10.00
IT875-2246-4	31.00	21.40	9.06	32.76	38.00	11.50
IAR11/48-2	29.50	18.66	8.40	29.99	26.17	12.33
IT87D-1143	25.33	16.43	8.08	40.50	33,83	12.33
OB89/312	10.67	11.81	5.53	17.68	31.67	10.00
OB89(3)	25.67	14.49	6.48	28.10	23.33	11.33
MAID-L	17.33	19.28	4.31	19.86	18.60	10.50
IF83-144A	18.33	9.18	4.23	17.26	23.17	10.00
OB89/2	18.82	8.28	3.81	17.09	20.33	9.67
MEAN	29.14	22.80	10.43	29.51	35.17	11.37
LSD(0.05)	16.74	6.90	3.04	11.02	9.69	5.90

Furthermore, when seedling and phenological traits having superior direct effects on grain yield were pooled with YGR and reassessed to quantify their effects on grain yield. YGR still had the most significant positive and direct effect on grain yield. This indicated that yield growth rate (YGR) was the most important physiological parameter with the most pronounced and desirable effect on the grain yield of cowpea (Table 11).

Table 11: Linear correlation and path coefficients between grain yield and some traits that showed superior direct effect on yields.

	E	DSF	100SW	YGR	Correlation with yield	Indirect Effect
E	**0.067**	0.015 (0.175)	-0.104 (-0.315)	-0.093 (-0.103)	-0.155	-0.182
DSF	0.012	**0.086**	-0.018 (0.054)	0.059 (0.066)	0.139	0.053
100SDW	-0.021	-0.005	**0.329**	0.233 (0.259)	0.537**	0.207
YGR	-0.007	0.006	0.085	**0.900**	0.984**	0.084

Figures underlined are direct effects of respective traits.
Figures in parenthesis are linear correlation coefficient values between traits measured

E= emergence trait; DSF= days to seed fill;
100SW= weight of 100 seeds; YDR= yield growth rate
**= Significantly different from zero at P= 0.01 level of probability.

In a separate study by Mr. T. H. Balogun, another graduate student of mine, we assessed the effects of six phenological and six morphological traits on cowpea yield. Only two of the six phenological traits viz days to 50% node formation and days to first flower formation and only two of the morphological traits i.e. number of peduncles per plant (NPP) and number of pods per plant (NPD) had significant effects on yield (Obisesan and Balogun, 2001). The two morphological traits are peduncle related since the number of peduncles has a direct correspondence on number of pods produced by the plant because the pods are carried on the peduncles. Obisesan (1986) and Obisesan and Mefoh (1986) reported that the branched peduncle character had a multiplier effect on the pod production potential of the cowpea plant (Plate 6). Obisesan (1987) reported that the branched peduncle character was positively associated with late maturity in all crosses. Consequently, cowpea plants with branched peduncles produced many pods but they were all late maturing. This tendency for the branched peduncle to be inherited together along with delayed maturity may be due to linkage or pleitropy .

Plate 6: Branched peduncles

The five highest yielding varieties were IFOB93/42A, IT90K-277-2, IT93K-876, IFOB/93/B and IT93K -624 with grain yields of 1670.5, 1385.8, 1285.1, 1247.1 and 1220.8 kg/ha respectively. The three highest biomass producing varieties at harvest maturity (Obisesan and Balogun, 2001) were IT90K-277-2, IFOB93/42A and IT93K-550 with mean biomass yields of 3719.72, 3624.40 and 3558.25 kg/ha (Table: 12).

Table 12: Mean values of twenty varieties of cowpea for some yield traits

Variety	100seed wt.	Grain yield(kg/ha)	Biomass yield(kg/ha)
IT89KD-349	12.13	1,014.0	3,330.2
IT89KD-245	20.81	890.0	2,680.4
IT89KD-260	19.14	950.8	2,971.3
IT88D-868-11	14.14	964.6	2,655.8
ART 91-2	10.04	1,127.0	2,637.2
IT89KD-391	14.70	1,090.7	3,347.1
IT89KD-374	14.11	1,047.9	3,384.1
IT90K-277-2	18.25	1,385.1	3,719.7
BPC	13.11	1,122.1	2,481.1
IT87D-590-5	16.77	983.3	3,197.1
IT90K-822-2	10.21	1,066.0	2,561.3
IT88D-643-1	15.96	1,004.9	2,358.4
IT93K-550	15.30	977.2	3,558.2
IT90K-59	12.21	1,200.0	3,170.5
IT93K-624	15.30	1,220.8	3,415.3
IT90K-102-76	14.54	948.5	2,495.8
IT93K-876	13.42	1,285.1	3,092.8
IT86D-719	13.86	816.9	2,469.4
IFOB93/42A	12.96	1,670.5	3,624.4
IFOB93/B	10.41	1,247.1	3,095.4

Varieties which combined high estimates of yield growth rate, yield accumulation per day of plant growth and yield per day of seed fill were consistently high grain yield producers. Our studies suggest that both the primary yield components as well as the morphological and developmental traits are very crucial traits to consider with a view to developing high yielding varieties of cowpea.

Heritability estimates for some yield components in cowpea

Heritability estimates quantify the proportions of phenotypic variances that is attributable to genotypic differences between individuals (Hanson, 1963). Lush (1949) defines heritability as that fraction of total variance within a segregating population attributable to genetic effects while Robinson *et al.* (1949) defined heritability as the selective genetic variance in percent of total variance. Heritability of a metric character is simply an index of transmissibility from the parents to the offsprings. Heritability estimates are commonly expressed in the narrow sense or broad sense while heritability in the narrow sense (h^2n) is defined as the ratio of additive genetic variance to phenotypic variance; broad sense heritability (h^2b) is the ratio of total genetic variance to phenotypic variance. Different methods of determining heritability have been reported (Lush, 1949; Smith and Kinman, 1965; Mahmud and Kramer, 1951; Warner, 1952). Heritability estimates of some economic traits in cowpea are presented in Table 14. The estimates were of tremendous assistance in our selection endeavours.

Table 14: Heritabily (h^2n) estimtes of some characters in cowpea

VGD	DPM	PDP	GRP (mg Day)	Pod length	No seeds /pod	SCR	100 seed wt	NPP	H I	YLD	Reference
				57	47	43	42	58		67	Emebiri and Obisesan (1988)
41	64	52	20								Emebiri and Obisesan (1991)
							46			39	Obisesan(1990)
				46 (63)	27 (43)	20 (54)	23 (44)				Ogunbodede(1984)
				(62)	(66)		(82)	– (14)	(21)		Apte *et al.* 1987
				– (98)	(68)		– (95)	– (67)	– (52)		Araujo and and Nunes(1983)

VGD=duration of vegetative period; DPM - days to pod maturity;
PDP= pod development period; GRP= growth rate of pods;
SCR= seed crowding; NPP= number of pods/plant;
HI= harvest index; YLD= grain yield/plant.

- = **figures in parenthesis are broad sense heritability** (h^2b) **estimates.**

Mutation breeding

During my fellowship year, tenable at the University of Naples, Department of Plant Genetics, Portici, Italy ,courtesy International Atomic Energy Agency, a mutation experiment was initiated (Obisesan,1994). From the advanced generations of the 'M1', 'M2' generations brought to Nigeria, a promising variety was developed from the irradiated variety A44/2. The mutant variety IFOB/01/94/B has a brown testa colour, a leathery pod texture, a pod length of 12 cm. and an unbranched peduncle and a hundred seed weight of 12 g. This variety is suitable for sole cropping at high population density, suitable for intercropping and has an upright compact architecture. Furthermore, it is early maturing (65days after planting) with synchronized maturity and resistance to the brown blotch disease . The variety is currently undergoing pre release evaluation field trials under the Nationally Coordinated Research Project on Cowpea.

Biotechnology : Tissue culture and regeneration studies

Cowpea plants are recalcitrant to regeneration '*in vitro*' and several attempts have been made to develop a reliable protocol for differentiating shoots from calli obtained through *in vitro* tissue culture. During the fellowship year, mature cowpea embryos, embryos with one cotyledon, complete mature seeds, apical and lateral meristems were tested as explants in regeneration studies on cowpea. The herbicide "thidiazuron" (TDZ-{1-phenyl-3 thiadiazol –5 yl} urea) was used as a growth regulator to induce lateral and apical multiple bud regeneration. They were scored weekly for callus growth, multiple bud regeneration, shoot and root formation. After two months of culture, TDZ at 10 or 20 μM gave the best result. Shoots obtained from regenerated multiple buds were successfully rooted and plantlets raised (Ciardi *et al.*, 1994). The raised plantlets were transformed using gene gun/microprojectile bombardment.

In 2003, a protocol for *in vitro* regeneration of avocado pear (*Persae americana*, Mill) was initiated during a three month leave spent at the Institute of Agronomy Campinas (IAC), in Brazil. Avocado pear is a tropical oil producing tree crop that is of common interest to Nigeria and Brazil. In Nigeria, the crop is underexploited and endangered. The investigation is on going (Obisesan, 2003b).

Development of New Varieties

Most of our varieties have been developed using the conventional breeding methods like Pedigree Selection, Single Seed Selection, Bulk population and Backcross breeding. The advantage of single seed descent over the other methods was highlighted (Obisesan, 1992).One variety was developed using mutation breeding. Dual purpose cowpea varieties (producing high grain and fodder yield) have been developed (Amujoyegbe and Obisesan, 1997; Balogun, 1999). The following elite and improved varieties IFOB99/94/DW, IFOB/01/94/B and IFOBWELL/01 have been submitted to the Nationally Coordinated Research Project (NARP) on Cowpea and are now at advanced stages of pre release national variety trials. The first one is white seeded while the last two are brown seeded. Breeder seeds of many other improved varieties are now available in the department .

Summary

Mr. Vice-Chancellor Sir, in the last one hour, I have tried to summarise my contributions towards yield improvement in the oil palm and the cowpea. Irrespective of the crop to be improved, be it a permanent crop, an annual crop or horticultural/vegetable crop and irrespective of the methods used for its development viz conventional breeding methods, mutagenesis or genetic engineering, the overt objective of the plant breeder is to increase the volume and quality of his improved varieties. In his quest to attain this objective, he inadvertently interacts with other specialists. It takes a team approach to win the optimum yield game. The Entomologists, Pathologists and Weed Scientists put in place crop protection packages while the agronomists provide appropriate production packages . Borlaug (1973) must have had these in mind when he called for interdisciplinary research among scientists in Agriculture.

Weather (climate) has a principal influence on agriculture and crop production. Establishment and strengthening of weather stations, fully equipped weather/meteorological stations, should be encouraged by government for accurate weather predictions to obviate crop losses or outright crop failure. Even though weather control and effect lie largely beyond the might of man, its year to year variation when properly observed, monitored and understood will be of tremendous assistance in food production planning. Establishment of such stations will also benefit other nonagricultural sectors of our national economy. The current efforts of Professor E.E. Balogun of African Regional Center for

Space Science and Technology Education and Dr. O.O. Jegede of Department of Physics, to attract a foreign grant to update the Meteorological Station of the Teaching and Research Farm of the Faculty of Agriculture of this University is a welcome development.
"Yield, the ultimate in crop improvement" is like a new born baby whose balanced development to adolescence is no longer the exclusive responsibility of the parents but that of the entire society and developmental processes to which that child may be exposed to in life. The plant breeder needs and shall continue to require the concerted efforts of collaborating researchers, funding agencies and government to sustain high yield per a given time **and also over time**. However, yield sustainability over time will be possible only when support facilities for plant breeding are optimum and there is a reservoir of rich plant genetic resources to fall upon by the plant breeder as specific needs arise over time. In order to attain the full potentials of plant breeding in any agricultural revolution and address the challenges which agriculture pose to plant breeding, genetic resources activities, as well as other aids to crop improvement, including biotechnology, should be encouraged (Tables 14 and 15). Problems inimical to plant breeding (Table 16) should also be addressed.

Table 14: Potentials of plant breeding in agricultural revolution

1. Developments of plants for increased yield
2. Development of plants for better quality.
3. Development of plants for uniformity of expression of desirable traits(early or late maturity, photo neutral plants, plants for predetermined height, lodging resistance etc.)
4. Development of plants for resistance to various stress environments (disease, insect pest, drought, cold, salt, etc).
5. Selection and development of plants for land scaping and erosion control.
6. Development of plants of aesthetic significance.
7. Creation and provision of new varieties for active research by other scientists in Agriculture.
8. Increase in production cycles of crops per given time (varieties amenable to high population densities, of early maturity, to various ecologies of a nation).
9. Conservation of plant genetic resources.

Table 15: Challenges to be met by Plant Breeding in Agriculture

1. Quantum supply of high yielding food crops.
   To meet the increasing population demand for food, plant breeding should:
   -Expand the pool of food crops in both variety and number
   -Develop varieties that achieve higher yields through Yield System Analysis pathway in addition to those developed through the conventional primary yield component pathway
2. Better quality of food crops.
   Highly nutritious food crops should be developed (e.g. quality protein should be incorporated into staple grain food crops.)- backcrossing and genetic engineering are very relevant.
3. Cost of production and environmental pollution.
   The plant breeder helps to reduce cost of production and increase profit margin of farmers by releasing crop varieties which are resistant to pests and diseases.
   He helps to prevent hazards to chemicals applicators and environmental pollution by making chemical application unnecessary through the release of resistant crop varieties.
4. Conservation of Plant Genetic Resources.
   The Plant breeder must endeavor to handover a richer genetic resources to the next generation succeeding him.
   Adequate conservation of old proven crop types and new ones should be done.
   Threatened crop species (shrines, agricultural, industrial, political pressures) should be rescued from extinction.
   In- situ, ex-situ and *in vitro* conservation measures to be put in place.
5. Meeting specialized needs of end users and industries.
   Breeding to meet the yearnings of numerous farmers and house wives.
   Regularly meeting the changing requests of industries in terms of quality, shape and size of farm products.
   Production of varieties whose products are compatible with mechanical harvesting.

Table 16: Problems inimical to Plant Breeding and Genetic Resources activities

1. Adulteration of Breeder Seeds and other breeding lines/germplasm at different stages of multiplication due to careless handling by supporting staff.
2. Consumption of seeds as grains.
3. Planting of seeds harvested from hybrid plants.
4. Controversy about safety of transgenic plants.
5. Low preference for training in Plant Breeding at the postgraduate level by young graduates in Agriculture/Biological sciences.
6. Poor funding of plant genetic resources activities (Prospection/Introduction, evaluation/Characterization, Conservation, Maintenance and Documentation). It is a capital – intensive venture and not as lucrative as other production aspects of agriculture.
7. Irregular electricity supply and poor infrastructural facilities. -In Nigeria, irregular electricity supply is a big clog in wheel of progress of plant breeding and allied disciplines.
8. Inadequate provision of opportunities for research staff to enjoy in service training and sponsored attendance of workshops and conferences related to their disciplines at the state, national and international levels. This trend normally denies scientists fora for interaction with professional colleagues and opportunities for cross fertilization of ideas.
9. Negligible participation by big time farmers and commercial entrepreneurs in research activities which are related to their interests. They can promote research activities by funding research projects in relevant departments of Universities, crop based Research Institutes, and creditable Non Governmental Organizations (NGOs).

Mr. Vice Chancellor Sir, may I suggest the following measures as a panacea for arresting further erosion of our plant genetic resources:

i. establishment of genetic resource units at the grass root level through out the country.

ii. conducting a survey of the country to obtain a compendium of endangered plants/crops , and ensuring its availability at all levels of government.

iii. clearance from Federal. State or Local Government officials before opening up of virgin lands for any developmental purpose involving large hectares.

iv. inspection of sites earmarked for clearing by accredited staff at all levels of government for the collection of endangered species before embarking on site clearing .

v. provision of adequate and sustained funding for plant genetic resource activities.

A rich plant genetic resource is a repository and spring board for dynamic research from which promising and diverse plants which may translate into crops (annual, horticultural, permanent, industrial or medicinal) of the future are released. This precious resource must be jealously preserved and expanded on a continuous basis. This will periodically inject radiance and variety into the agricultural crop production system and the life of the citizenry in general. Governmental , Non Governmental Organizations and indeed individuals, have roles to play by complementing the efforts of the plant breeder and allied genetic resources workers as major stake holders in the provision of improved and high yielding crops for today and tomorrow.

Mr. Vice Chancellor Sir, distinguished audience, I thank you for your attention. God bless you all.

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