FUNAAB
INAUGURAL LECTURE SERIES

FROM GRASS TO GRACE: AN EXPOSITION ON WESTERN AND TRADITIONAL CROPPING SYSTEMS

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FUNAAB INAUGURAL LECTURE Series No. 45
Wednesday, 4th June, 2014

FUNAAB
INAUGURAL LECTURE SERIES

This 45th Inaugural Lecture was delivered under the Chairmanship

of

The Vice-Chancellor
Professor Olusola B. Oyewole
B.Sc. (Ife), M.Sc., Ph.D. (Ibadan)

Published 4th June, 2014

ISBN:

Series No. 45: Professor P.O. Adetiloye

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1.0 Preamble

An inaugural lecture provides an opportunity for a Professor to profess his professorship based on his/her years of teaching and research experience, years of administrative experience and services to the community, the nation and to humanity in general. It is a requirement for all Professors. An inaugural lecture also gives an opportunity to look back and make forecast for future research directions. The more one learns, the more one realizes how limited is our knowledge about Nature; the more one realizes how much still needs to be learnt. Though, an expert in my field of specialization which is cropping systems, I am still a student of Nature and I will continue to be a student of Nature, hence it is with all sense of humility that I stand before this great audience today to present this inaugural lecture titled: "**FROM GRASS TO GRACE: AN EXPOSITION ON WESTERN AND TRADITIONAL CROPPING SYSTEMS"**

This is the first inaugural lecture from the Department of Plant Physiology and Crop Production, in which I served as the first Head of Department from 1996 to 2001. This is also the first inaugural lecture on Cropping Systems, and more so an inaugural lecture that attempts to provide an insight into the complexity, challenges and advantages of Western and African traditional cropping systems. My research experience at the University of Nigeria Nsukka, and my research experience as a PhD Research Fellow at the International Institute of Tropical Agriculture (IITA) Ibadan from 1977 to 1980 and my research works as a young Lecturer at Obafemi Awolowo University from 1981 to 1989 and later at the Federal University of Agriculture, Abeokuta from 1990 to date in cropping systems, provided me the insight to unravel the intrinsic logic in Western and African traditional cropping systems as we shall soon see.

2.0 INTRODUCTION

What is a system? A system is an aggregate, or a compendium of functional variables, or components, or factors or entities that are interacting to produce an end result or output.

What is a cropping system? A cropping system is an aggregate of resource inputs that are combined in a given space and time in crop production for food and profit.

The inputs include:

i. Growth factors (light, soil moisture and soil nutrients)
ii. Production technology
iii. Crop species and genotypes
iv. Managerial capacity
v. Arable land

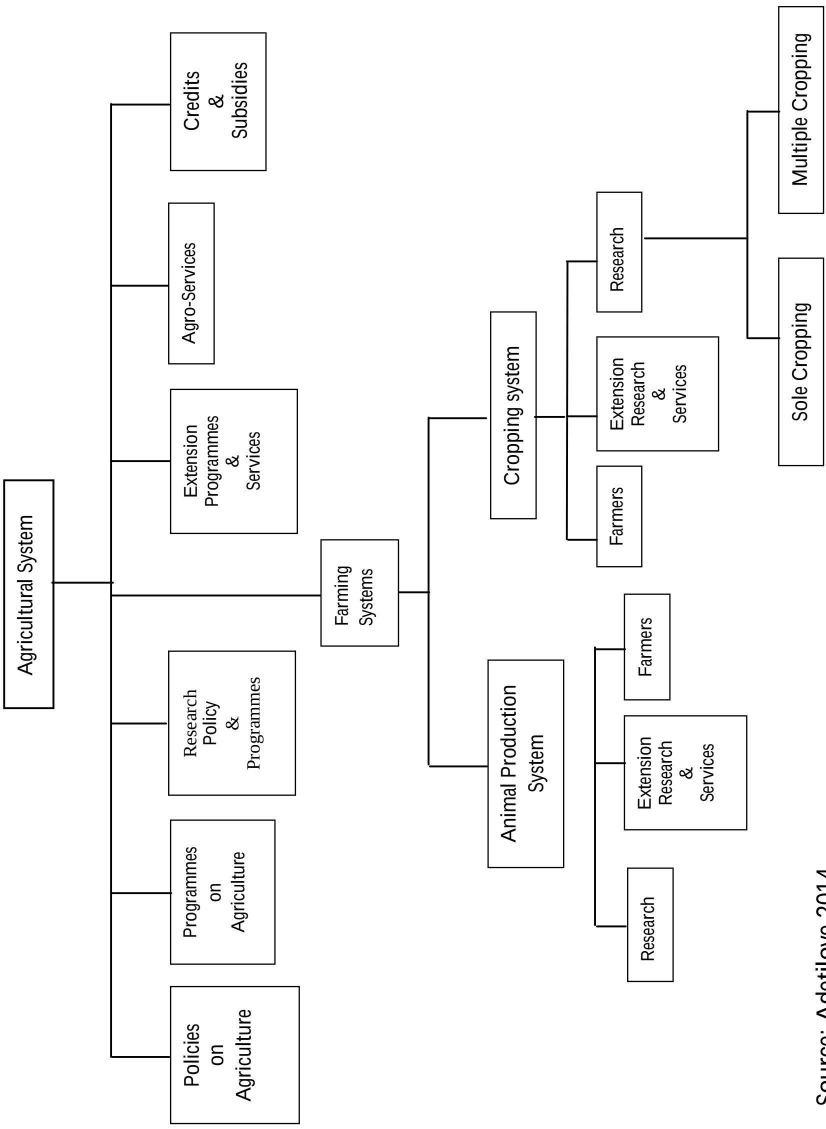
The quality and quantity of these resource inputs and how they are combined will produce different kinds of cropping systems.

Cropping systems, therefore, vary from one ecological zone to the other due to the following

- Differences in climatic conditions
- Differences in the crop diversity that a given agro-ecology can support
- Differences in production technology and
- Differences in socio-economic factors.

A cropping system is a sub-system of the farming systems, in that farming systems include a range of cropping systems and a range of animal production systems.

Farming system is also a sub-system of the Agricultural system. The interacting components in the Agricultural System include policies and, programmes on agriculture, availability of capital, prevalent Farming systems, research support, extension support, availability or otherwise of agro services,



Source: Adetiloye 2014

Figure 1: Schematic Relationships among the Agricultural System, the Farming Systems and Cropping Systems

availability or otherwise of credits and subsidies to farmers (Figure 1)

2.1 Systems' Performance and Evaluation

The elegance of the systems theory and approach is that the performance or productivity of a system is not determined by the factors that are in optimum supply but by the factor or factors that is or are insufficient or limiting.

The implication of the Law of Limiting Factors propounded by Liebig in 1862 (Mitchell 1970) is that even where researchers come out with highly productive and profitable cropping systems and recommend the best management practices that farmers could adopt, agricultural production in Nigeria will not have the desired impact on economic development as long as any one of the other components of Agricultural System is not adequate or is limiting in supply.

As the supply of the limiting factor or factors improve(s), the performance of the system will improve correspondingly. This law has also been described with subtle differences in emphasis by Mitcherlich in 1909 as the Law of Optima and Limiting Factors (Mitchell 1970). For example, the human body is a system that is made up of distinct components or sub-systems; the nervous system, the blood circulatory system, the respiratory system, the digestive system, the excretory system, the endocrine system and the reproductive system. If just one of these seven sub-systems is sick while the others are working perfectly, the entire body will be sick and the person will not be able to perform normal functions. As you medicate and alleviate the pain of the malfunctioning or sick part of the body, the entire human body will be getting better and better as that part of the body gets better.

My research works in the last 34 years as an agriculturist in the University teaching and research profession focused on Cropping Systems Research. This is the focus of this lecture.

2.2 Goals of Cropping Systems Research

The four goals of cropping systems research are:

1. How to improve productivity in terms of crop yields and income
2. How to achieve sustainable yield and sustainable land use
3. How to increase yield stability with hazards of drought, pests and diseases and
4. How to achieve equitable use of resources all year round

Cropping systems research is usually designed to address one or more of these goals at a time

2.3 Types of Cropping Systems

There are two major types of cropping systems. These are;

1. Sole cropping system sometimes called mono-cropping system and
2. Multiple cropping system

2.3.1 Sole Cropping System

This is the practice of growing one crop on a piece of land at a time. It is the predominant cropping system among industrial nations such as USA, Europe, Canada, and Australia. A farmer can have 100 to 500 hectares planted to maize or rice or soya bean alone.

Some of the characteristics of sole cropping are;

1. Farm operations such as land preparation, planting, fertilizer application, weed control, harvesting and processing can easily be mechanized.
2. Production is oriented towards profit maximization in industrialized countries.
3. Market outlets for farm produce and products are therefore both national and international.
4. Sole cropping system is, however, prone to risks associated with build-up of pests and diseases over time.
5. It also leads to physical and chemical degradations of the soil; most especially in fragile tropical soils.

2.3.2 Multiple Cropping Systems

Multiple cropping is the traditional cropping system that is

prevalent among resource-poor farmers in Africa, Latin America and South-East.
Multiple cropping involves growing two or more crops on the same piece of land at the same time or growing one crop more than once in one year.

Multiple cropping systems are practised to maximize the use of rainfall, land, soil nutrients, solar radiation, family labour and hired labour in order to provide all year-round food and income for the farm family. Traditional multiple cropping Systems are characterized by:

1. Small farm sizes that range from 0.5 – 2.0 hectares
2. Use of traditional or rudimentary technology; Hoes and cutlasses
3. Use of family labour and a few hired labour
4. Two to ten or more crop species can be planted simultaneously on a piece of land at the same time, thereby giving more yield per unit land area than sole cropping
5. Multiple cropping enhances the efficiency of land use and of growth factors
6. It is not so profitable when practiced on a small scale and I am sure no University graduate can earn a meaningful living with hoe and cutlass farming on one or two hectares of farm land.
7. Production is partly for subsistence and partly for small incomes.

8. The diversity of crops in multiple cropping systems reduces the risks of build-up of pest and deceases that associate with crops in sole cropping.
9. Multiple cropping provides continuous cover for the soil, thereby preventing chemical and physical degradations of the soil.
10. In case of drought or flooding, traditional multiple cropping systems can provide some security for farmers in that all the crops cannot fail at the same time.

The major criticism about African traditional multiple cropping systems is that they cannot be mechanized because many crops are usually planted together on small scale in intercropping mixtures. Our research findings show that African traditional multiple cropping systems can be successfully and profitably practised on large scale if the constraints of cash and machinery for land preparation are eliminated.

Classification of Multiple Cropping Systems

Multiple cropping systems can be classified on the following basis:

1. Spatial and temporal arrangements of crops on the land as;

Mixed intercropping: This involves growing two or more crops simultaneously on the same piece of land without distinct row arrangement.

Row Intercropping: This involves growing two or more crops simultaneously on the same piece of land in different rows.

Relay Intercropping: This involves planting a crop on a field that is already planted to another crop; shortly before the first crop is harvested. E.g. planting cassava on the side of yam heaps just before yam is due for harvesting.

Strip intercropping: This involves growing two or more crops together in strips of about four or more rows per crop such that the intercrops interfere minimally with one another.

Sequential cropping: This involves growing the same or another crop on the same piece of land after harvesting the first crop. When this involves one crop after another it is called double cropping. It is called triple cropping when another crop is introduced within one year after harvesting the second crop. It could also be quadruple cropping when four crops are planted one after the other sequentially on the same land in one year.

Crop rotation: This involves planting three or four crops in a definite sequence over three or four years to take advantage of differences in their rooting depths and to avoid buildup of pests and diseases.

Shifting Cultivation: This involves a situation in which a farmer crops a piece of land for one or two years before moving to another piece of land that has remained on fallow for four or more years. The cultivated land is then left fallow for four or more years to build up the soil fertility from litters incorporated into soil by decomposition and activities of soil inhabiting organisms.

2. *Major crop in the system as:*

Cereal based cropping system; e.g., maize based or rice based cropping system

Tuber based cropping system; e.g., cassava based or yam based cropping system
Perennial crop based cropping system; e.g., Oil palm, or Cocoa based cropping systems

Agro-forestry system; cultivation of various trees along with food crops

3. *Production ecology as:*

Arid or dry land cropping systems: These are cropping systems that are found in arid regions of the world where rainfall lasts for one or two months in a year

Upland or rain-fed cropping systems: These are cropping systems that are suitable for regions that enjoy regular rainfall for three to nine months in a year.

Lowland cropping systems: These are cropping systems that benefit from the soil moisture associated with lowland swamps and river basins without the need for irrigation during the dry season. Such lowlands become flooded or partially flooded during the rainy periods.

Irrigated cropping systems: These are cropping systems that depend on artificial supply of water through irrigation. They can be found in uplands where supplemental irrigation is used during protracted drought or when full irrigation is used when the raining period has ended. It is also found in arid regions of the world. They are capital intensive.

2.4 THE SCIENCE OF AGRICULTUTAL RESEARCH

Agriculture is a multidisciplinary science. It involves the study and understanding of various science disciplines that are required for good understanding of the performance (growth, development and productivity) of crops and livestock. These science disciplines include; Biology (taxonomy, physiology and anatomy), Chemistry, Biochemistry, Microbiology, Physics, Statistics, Mathematics, Agro-climatology, and Economics. Thus agriculture is an applied science.

The importance of three of these inter-related disciplines in cropping systems research will be highlighted here.

2.4.1 The importance of Mathematics and Statistics in cropping systems research

Agricultural researches that lead to significant improvements in crop production are carried out with rigorous scientific methodology. This entails, finding out the challenges that farmers face in crop production, and designing appropriate experiments that can lead to useful inferences and solutions to the challenges of farmers.

The data obtained from such experiments can provide quantitative information on how crops respond to inputs and variable conditions of nature in the environment. Hence, research data speak to scientists about crops and also about the environment.

In addition, scientific data can lead a scientist to formulate mathematical expressions and mathematical models that describe how crops perform in different situations and environments. This is because data on crop performance show patterns that can be mathematically described or modeled.

Mathematics then, is a universal language of nature. Crops, the environment or nature, can be mathematically understood because nature is intelligently designed and therefore intelligible.

2.4.2 The Importance of Agro-climatology in Cropping Systems Research

Rainfall, temperature, humidity, solar radiation are major environmental factors that influence crop growth, crop development and yield. The time of planting and harvesting are determined in rain-fed agriculture by the annual cycles of the early and late cropping seasons in Southern Nigeria and the monomodal rainfall pattern of Northern Nigeria.

Farmers can predict the annual cycles for planting and harvesting until the recent phenomenon of climate change started posing serious threat on the onset, duration and intensity of rainfall in Nigeria and other parts of the world. Climate change results in unpredictable rainfall patterns, sudden flooding of crop fields or protracted dry spell or drought that can devastate regional crops thereby leading to extensive crop failure under severe weather conditions.

In addition to abnormal rainfall patterns, climate change is also associated with severe heat waves that can positively or negatively affect the development of crop plants, pests, diseases and the human population. This severe heat wave is also responsible for the common experience of many people for not being able to sleep at night in recent times because heat wave affects the sleep hormone in the brain.

The need to monitor climatic variations in order to mitigate climate change and to adapt crop production practices to unpredictable changes in climate and to ensure that our planet does not become inhospitable to humans and other living things has become more urgent now than before.

2.4.3 Role of Crop Physiology in Cropping Systems Research

Crop physiology entails the study of how growth and developmental processes in crops determine crop yield. It entails an understanding of how plants harvest the energy of the Sun during photosynthesis, how soil nutrients and moisture uptake affect the biochemical processes in crops, leading to crop yields. It should be noted that the fire from a burning bush is the amount of fire or energy of the sun that the plant community captured from the onset of its growth and the time it ignited fire, either by accident or through deliberate human action. It is therefore worthy of note that, each time we eat any type of food; plants or animals we should remember that we are consuming the energy from the Sun. In short the Sun is the provider of "our daily bread."

Crops can be manipulated culturally and genetically to optimally exploit environmental resources for optimal yield. Crop scientists, therefore, endeavour to ensure that the physiological processes that result in crop yield function optimally.
Any physiological process (photosynthesis, transpiration, respiration, floral induction, reproduction, seed development, etc.) that is limited by the supply of any environmental resource will correspondingly reduce crop growth, development, and yield.

The understanding of how crops capture environmental resources in the field is relatively straight forward for sole crops, provided weeds, other pests and diseases are controlled.

The physiological processes that determine crop growth and yield in intercropping systems become trickier to manipulate when two or more crops are planted together on the same piece of land during part or the entire period of their growth during which they share light, soil moisture, soil nutrients, and space. Cropping systems research, whether in sole cropping or multiple cropping systems is aimed at manipulating crops and the environment culturally, through the use of quality seed for planting, choice of appropriate planting density, optimum plant arrangement in the field and optimum time of planting as well as nutrient balancing, control of weeds, insects and diseases and genotype manipulation for maximum yield.

A cropping systems scientist must therefore understand how crops can perform optimally in sole cropping in order to understand how crops can perform optimally in multiple cropping systems.

3.0 MY CONTRIBUTIONS TO CROPPING SYSTEMS RESEARCH

In Nigeria, Agricultural research that started from the colonial days focused on Western type of cropping systems, which is highly mechanized, and highly dependent on input of chemical fertilizers, insecticides and herbicides in mono-cultural cropping. It was not until the early 70s that significant research efforts were directed by scientists towards understanding why African farmers prefer complex multiple cropping systems to the relatively simple sole cropping method, that is commonly practiced in Western and highly industrialized countries.

3.1 CROP PHYSIOLOGY RESEARCH ON SOLE CROPS

3.2 Cowpea Seed Quality Research

The Problem: One of the problems faced by cowpea farmers in Southern Nigeria is that the seed quality of cowpeas can be reduced when rain falls on the dry pods prior to harvest. Delay in harvesting often leads to pod and seed infestation by insect pests in the field thereby leading to rapid deterioration in seed quality during storage. The storage pests are carried to

Either problem will reduce the germination of cowpea seeds if planted and the quality of the seeds as food if cooked for eating. The problem is that cowpea pods do not mature at the same time; hence they are selectively harvested at dry maturity stage. This could take three or more harvests that could span up to three weeks.

Research Approach: At University of Nigeria, Nsukka, seeds of cowpea were evaluated for seed characteristics, seed maturity, germination, and seedling vigour when harvested at 3, 6, 9, 12, 15, 18, 21 and 24 days after the fertilization of the flowers. Seed characteristics were monitored daily from 24 to 26 days after flowering.

Results and Recommendations: Cowpea seeds attained maximum bulking or size at 18 days after flowering which was when the seeds attained physiological maturity. At this stage the green pods turned yellow. Thereafter, the pods started drying and by the 26 days after flowering, it attained dry maturity or harvest maturity (Tables 1). Cowpea seeds attained good germination as from 15 days after flowering (Table 2).

It was, therefore, recommended that cowpea seeds could be harvested at 18 days after flower set when the pods turned yellow and when wetting by rain or infestation by field pests would have minimal effect on seed quality and germination, provided it can be oven dried or sun dried (Adetiloye and Ezedinma, 1978).

Table 1: Relationship between time of pod set and various seedling characteristics of cowpea seeds sown fresh and air-dried at maturity

Mean Seed Characteristics	Days After flowers Open										
	9	12	15	18	21	22	23	24	25	26	26+Rain
Fresh Weight (mg)	0.078	0.190	1.260	2.872	3.454	3.165	2.495	2.057	1.956	1.886	2.342
Dry weight (mg)	0.008	0.027	0.215	0.850	1.682	1.679	1.710	1.691	1.706	1.689	1.762
Seed Size (mm^2)	-	-	25.700	53.700	54.430	48.940	44.280	32.840	31.500	31.460	42.530
Moisture (Percent)	89.74	85.810	82.930	70.400	51.300	46.950	31.460	19.790	12.780	10.440	24.760

Source: Adetiloye and Ezedinma (1978)

Table 2: Effects of stage maturity on emergence and seedling characteristics of Cowpea seeds, sown fresh and air-dried

Seed and Seedling Characteristics	Seed Maturity (Days After Flower Opening											
	9		12		15		18		21		26	
	Fresh	Dry	Fresh	Dry	Fresh	Dry	Fresh	Dry	Fresh	Dry	Fresh	Dry
Days to Emergence	0	0	0	0	9	7	7	4	4	3	4	3
Duration of Emergence (Days)	0	0	0	0	-	7	6	4	4	4	4	3
Emergence (Percent)	0	0	0	0	4	70	74	96	96	98	100	100
Area of Simple leaves (cm^2)	0	0	0	0	-	16.28	26.50	37.90	38.32	44.90	44.05	43.90
Total Leaf Area (cm^2)	0	0	0	0	-	65.15	79.12	133.70	158.00	210.70	205.90	216.00
Seedling Dry Weight (g)	0	0	0	0	-	0.32	0.39	0.52	0.61	0.80	0.79	0.81

Source: Adetiloye and Ezedinma (1978)

3.1.2 Research on low maize grain yield in the humid tropics

The Problem: Maize in the humid tropics produces comparable biomass with maize in temperate regions of the world. This notwithstanding, grain yield of maize in the humid tropical environment is about a quarter of that in temperate countries. We wanted to find out whether this was caused by the environment constraints rather than genotype.

Research approach: Maize was planted at different plant populations and different fertilizer levels in the early and late cropping seasons on the research Field of the International Institute of Tropical Agriculture (IITA) Ibadan, a less humid zone, and at IITA Research Field in Ikenne in the high rainfall zone to determine their performances.

Results and recommendations: It was found out that when different environmental resources were limiting, it affected different parts of maize crop in the vegetative and reproductive stages thereby reducing yield through these combined effects as summarized in Figure 2. The environmental factors (light, soil moisture, and soil nutrients are represented by the triangles that point upwards for the maize plant shoot (vegetative phase) and for the maize ear shoot (reproductive phase). The downward pointing triangles are the maize plant and ear shots parts that are affected by the growth factors in the opposite angles (the growth factors triangle). If for instance, the soil moisture angle is reduced by halve during vegetative growth, it will reduce growth of leaves, photosynthesis and grain yield at the center (hexagon) by halve. Similar reduction in soil moisture in the reproductive phase will further reduce husk growth and the maize grain yield by halve.

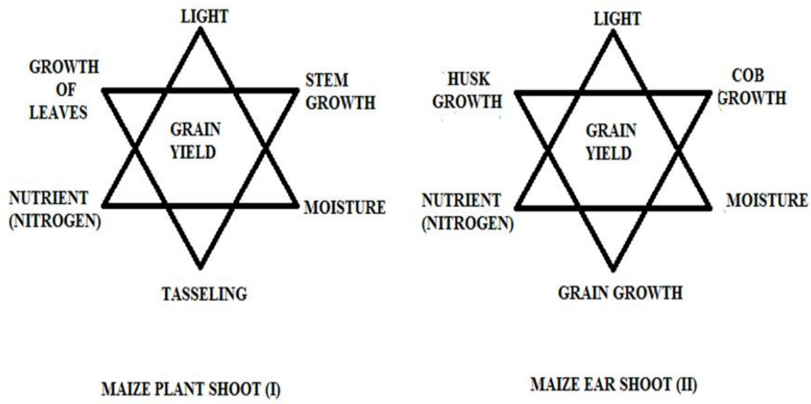


Figure 2: Schematic illustration of the interactions among trait-specific growth factors and maize plant parts in relation to maize grain yield

Maize grain yield and grain to ear weight ratio were reduced at Ikenne (Table 3) notwithstanding, the high dry matter yield of maize due to too much cloudiness that limited solar radiation income and therefore limited photosynthesis. (Adetiloye, *et al*., 1984)

It was recommend that maize can attain its yield potential in the humid tropics with optimum fertilizer application and supplemental irrigation during dry spells. Maize also gave best yields during high sunshine periods provided soil moisture and soil nutrients were in optimal supply.

3.1.3 Tatase (*Capsicum annum*) fruit production research

The Problem: A survey of cropping systems in Ogun State in 1990/91 revealed that farmers in Ijale Papa found it difficult to successfully grow tatase pepper, which is grown in the North and brought to the South in trailer loads. They complained of poor germination, poor establishment and poor growth after transplanting, poor fruiting and premature fruit drop. That is, the fruits drop when still green well before they ripen.

Research Approach: At FUNAAB we carried out green house and field experiments over two years to resolve these problems.

Table 3: Maize grain and dry matter distribution within the ear as influenced by location and season, plant population and nitrogen fertilization

Location and Season	Grain Yield (g/m^2)	Grain: Ear ratio	Husk: Ear ratio	Cob:Ear ratio
Ibadan 1977, late cropping season	184	0.617	0.212	0.175
Ikenne 1977, late cropping season	158	0.615	0.205	0.180
Ibadan 1978, early cropping season	364	0.718	0.153	0.132
Ikenne 1978, early cropping season	317	0.662	0.197	0.144
LSD 5%	139	0.011	0.013	0.011
Maize Density Plant per Ha				
15,000	174	0.632	0.204	0.166
30,000	270	0.656	0.190	0.156
45,000	324	0.671	0.181	0.151
LSD 5%	49	0.100	0.009	0.010
Maize Nitrogen Level (Kg/Ha)				
0	225	0.648	0.881	0.165
30	260	0.654	0.192	0.158
45	282	0.657	0.196	0.150
LSD 5%	9	0.003	0.002	0.004

Source: *Adetiloye et. al.*, (1984)

Results and Recommendations: It was found out that poor germination of *Capsicum annum* seeds was caused by the fact that more than 50% of the seeds had very little food reserve in the embryo. Such seeds could not germinate. Secondly, the hard seed coat of the good seeds prevented germination if the soil remained dry without rains or inadequate watering in the nursery.

It was found out that uprooting the seedlings for transplanting resulted in transplanting shock that reduced subsequent growth and yield.

It was also confirmed that transplanted *Capsicum annum* seedlings that established showed poor growth and the few pods produced dropped because the pods were punctured by the Mexican fruit fly while it laid its eggs in the pods. That resulted in partial fruit rot that sent signal to the plant to drop such fruits prematurely.

It was recommended that light seeds with little or no food reserve in the cotyledons should be separated from heavy seeds immediately after extraction from the fruits by simple sedimentation in water. The heavy seeds that gave almost 100% germination stayed at the bottom of the container while the light seeds that floated in water gave very low percentage germination and should be discarded.

Table 4 showed that heavy but dry seeds gave almost 100% germination by soaking in water for twelve hours to soften the seed coat before planting in the nursery (Adetiloye, 2004).

It was also found out that conventional transplanting by up-rooting damaged the roots thereby causing transplanting shock, poor growth and poor fruiting. It was observed that raising the seedlings in small pouches and planting the seedlings with degradable pouches in the field prevented transplanting shock, gave good growth and excellent fruiting. Such pouches are industrially produced in large quantities in developed countries and can be mass produced in Nigeria. I called this trans-panding technique because unlike in transplanting technique, the seedlings were not uprooted.

It was found out and recommended that tatase pepper can be grown in Southern Nigeria in the late or dry season during which the Mexican fruit fly is not common, and if possible under irrigation. If grown in the early season, the green fruits should be sprayed with contact insecticide at low concentration at least two weeks before ripening.

3.1.4 Legume Nitrogen Fixation Research

The Problem: Grain legumes, unlike cereals, can easily grow on low fertility or poor soils because legumes can fix their own nitrogen from the free nitrogen in the air within the soil roots

Table 4: Effect of seed weight and length of soaking on emergence rate, plant height, leaves per plant, shoot fresh and dry

	Emergence				Shoot	
	%	Rate/ Day	Plant Height (cm)	Leaves Per Plant	Fresh Weight (gm)	Dry Weight (gm)
LIGHT SEEDS						
Soaking Hours 0Hr	50	4a	7.5c	10b	0.380b	0.039c
6Hr	60	5a	8.3b	11a	0.400ab	0.043b
12Hr	65	5a	8.3b	11a	0.408ab	0.043b
18Hr	64	5a	9.0a	11a	0.449a	0.045a
HEAVY SEEDS						
Soaking Hours						
0Hr	78	8b	8.8b	10b	0.400ab	0.040c
6Hr	89	9b	9.1ab	11a	0.412b	0.042b
12Hr	96	10b	8.9b	11a	0.485a	0.047a
18Hr	98	10b	9.5a	12a	0.520a	0.051a
MEANS OF MAIN EFFECTS						
Light Seed	60	5b	8.3b	11a	0.409b	0.043b
Heavy Seed	90	9a	9.1ab	11a	0.454a	0.045a
Soaking Hours						
0Hr	64	6c	8.2c	10c	0.390b	0.04d
6Hr	75	7b	8.7b	11b	0.406b	0.043c
12Hr	81	8a	8.6b	11b	0.447a	0.045b
18Hr	82	8a	9.3a	12a	0.048a	0.048a

Source: Adetiloye (2004)

because of its symbiotic relationship with the soil bacteria called *Rhizobium.* Different grain legumes show *Rhizobium* strain specificity.

Unlike commercial fertilizers, *Rhizobium* inoculants that are impregnated or coated on seeds before planting are cheap and affordable. Unlike chemical fertilizers, inoculants can not be leached away from the root zone. Inoculants do not cause physiological acidity of soils, which commercial nitrogen fertilizers cause.

Research Approach: At the Soyabean and Alfalfa Research Lab. of the US Department of Agriculture (USDA) in Maryland USA, 30 peanut strains of *Rhizobuim* were screened in green house bioassay (Adetiloye, *et al.,* 2001).

The *Rhizobia* inoculant research was continued here in FUNAAB. Several soyabean cultivars and *Rhizobium japonicum* strains were evaluated with different local carriers for Rhizobium broth cultures.

Results and Recommendations: At the Soyabean and Alfalfa Research Lab of the USDA, a new strain of *Rhizobium* (USDA 4444) that produced very good growth and flowering of peanuts was discovered during the bioassay (Table 5).

Table 5: Foliage pigmentation, flowers per plant, nodule size dry matter yield and acetylene reduction of peanut (*Arachis hypogea)* as affected by inoculation

Strain	Foliage Pigmentation 30 DAP	Flowers Per Plant 40DAP	Nodule Size 66 DAP	Dry Matter Yield/Plant (mg) 66DAP	C_2H_2 Reduction mol/hr/mgdm 66 DAP
No Strain	1	1	1	1403	1.069
USDA 3179	4	18	2	5592	1.19
USDA 3180	4	9	2	4070	1.766
USDA 3181	4	2	2	3379	1.032
USDA 3183	2	5	1	995	0.219
USDA 3184	3	5	2	3284	1.37
USDA 3185	4	3	2	1111	0.615
USDA 3186	4	17	4	4747	0.74
USDA 3187	5	11	4	7621	3.107
USDA 3188	3	6	2	4184	2.707
USDA 3337	4	9	4	5245	2.821
USDA 3338	4	11	2	4811	2.535
USDA 3339	3	4	2	1845	1.017
USDA 3340	5	14	2	5436	1.905
USDA 3341	5	20	4	6434	1.698
USDA 3342	5	17	2	4719	2.202
USDA 3344	3	3	4	4861	2.391
USDA 3345	4	6	4	4549	2.261
USDA 3384	4	1	4	1151	0.0577
USDA 3451	4	4	4	6239	4.259
USDA 3456	4	13	2	5498	2.042
USDA 3518	4	1	4	2275	1.055
USDA 3519	5	11	4	3101	1.732
USDA 3520	4	17	4	3690	2.692
USDA 3521	4	12	4	5541	3.351
USDA 3522	4	9	4	5107	3.906
USDA 4441	4	2	2	2119	2.37
USDA 4442	4	7	2	5643	2.198
USDA 4443	4	9	4	3842	1.644
USDA 4444	4	25	4	8755	3.232
USDA 4445	4	11	4	5341	2.9
All-Strain	5	10	4	6006	2.786
S.E	±4	±6	±1	±1867	±0.98

Foliage Pigmentation Score: 1-yellow, 2-slightly yellow, 3-Slightly green, 5-Deep green
Nodule size score: Control (no nodule)-1, small nodules-2, medium nodules-3, big nodules-4

Source: Adetiloye *et al*., 2001

At FUNAAB, the effect of seed inoculation and chemical weed control were evaluated on four soyabean cultivars. The results presented in Table 6 showed that spraying of herbicides did not have any significant effect on the inoculated seeds. Inoculation significantly improved the seed yield and Harvest Index (HI) of four soyabean cultivars (Adetiloye and Salau, 2000).

The effects of three local carriers for Rhizobium broth culture were investigated on six soyabean varieties. The best carriers were Peat soil and *lafun* (from cassava) which provided best responses in terms of nodule numbers per plant and seed yield as shown in Table 7 (Soretire *et al*., 2002).

Rhizobium germplasm collections are stored at near freezing temperatures. The incessant power failure disrupted our *Rhizobium* germplasm collection and this has been the greatest challenge to our nitrogen fixation research.

3.20 CHALLENGES IN INTERCROPPING RESEARCH – HOW MIND WORKS

Three challenges in intercropping research methodology were identified in the early years of my cropping systems research as a PhD student of University of Nigeria Nsukka; when I was sponsored through Ford Foundation Fellowship to carry out the research at IITA, Ibadan.

Table 6: Seed yield, number of pods per plant, 100-seed weight and harvest index of soybean plant as affected by cultivars, *Bradyrhizhobiunm* inoculation and weed control in 1996 and 1997 cropping seasons

	1996					1997				
	Short dry Weight/ Plant (g)	Seed Yield (g/10m2)	No of Pod/ Plant	100-Seed Weight (g)	Harvest Index (%)	Short dry Weight/ Plant (g)	Seed Yield (g/10m2)	No. of Pod/ Plant	100-Seed Weight (g)	Harvest Index (%)
Cultivars										
TGX 1485-1D	3.9	904.1	15.1	13.7	0.6	4.8	1059.5	30.1	14.9	0.6
TGX 1740-2F	5.4	109.2	21.1	12.6	0.5	5.4	974.9	31.7	13.9	0.5
TGX 1448-2E	5.5	458.3	18.1	9.8	0.3	4.5	718.9	25.9	13.8	0.5
Samsoy 2	6.4	579.3	18.2	10.5	0.3	4.7	969.9	28.7	14.4	0.6
LSD, 5%	0.5	158.8	N.S	0.7	0.1	0.4	188.3	3.3	0.6	0.1
Bradyrhizobium Innoculation										
Innoculated	5.3	829.9	21.2	11.7	0.5	4.9	1041.7	29.9	14.4	0.6
Un-innoculated	5.2	686.4	15	11.6	0.4	4.8	819.9	28.2	14.2	0.5
LSD, 5%	N.S[1]	85.2	3.4	N.S	0.1	N.S1	133.1	N.S	N.S	0.1
Weed Control										
[2]Galex1.5kg a.i/ha	5.4	773.2	20.7	11.7	0.5	5	959.2	29.1	14.2	0.5
Hand Weeding	5.1	743.1	15.3	11.7	0.5	4.7	902.6	29.1	14.3	0.5
LSD 5%	N.S	N.S	3.4	N.S	N.S	N.S	N.S	N.S	N.S	N.S

[1]NS= Not Significant
[2]Galex is proprietary mixture of Ciba-Geigy, Bassal, Swizerland containing 250g/l melachlor [2-chloro-N-(2-ethyl-6-methyl phenyl)-N-(2-methoxy-1-methylethyl acetamide)] plus 250g/l metobrumuron [N'-4(4-bromophenyl)-N-methoxyl-N-methyl urea]
Source: Adetiloye and Salau, 2000

Table 7: Effect of soyabean cultivar, type of carrier and soil sterilization on nodules per plant, nodules size at 10wap and grain yield pert plant of soyabean at harvest

S/N		Nodules Plant^{-1}	Nodules Size	No of Pods Pods Plant^{-1}	Grain Yield Plant^{-1} (g)
	Cultivar				
1	Samsoy-2	9.5a	2.8a	11.2ab	5.70a
2	TGx 1805-17F	4.9c	2.7a	10.0ab	5.15ab
3	TGx 1681-3F	7.5b	2.6ab	6.3d	2.31ab
4	TGx 1448-2E	7.2b	2.5abc	12.2a	5.31ab
5	TGx 1740-2F	10.3a	2.3c	9.3c	4.68b
6	TGx 1789-7F	6.8b	2.4bc	10.3bc	4.85b
	Carrier				
1	Control	3.5c	2.3c	11.1b	3.54c
2	Peat	8.2b	2.8a	16.2a	5.54a
3	Lafun (Cassava Flour)	10.3a	2.5b	16.4a	4.8ab
4	Moss	3.5c	2.8a	16.7a	4.70b
	Soil				
1	Sterilized	8.18a	2.72a	8.29b	3.56b
2	Unsterilized	7.18b	2.49b	11.75a	5.77a

Source : Soretire *et al*., 2002

Sleepless nights for days, weeks and months were spent to resolve these puzzles and the answers I got became bewildering to imagination.

The Identified challenges were resolves as follows:

3.2.1 Evaluation of agronomic advantage and compatibility

Land Equivalent Ratio (LER): The LER was the common index for evaluating yield superiority (agronomic advantage) or otherwise of intercropping systems over sole cropping (Willey 1969) prior to my PhD research.

The LER is computed as follows:
LER = ya/Ya + yb/Ya for a mixture of two crops.

Where ya and yb are the yields of crops A and B in intercropping while Ya and Yb are the optimum sole crop yields.

An LER value of 1.5 indicates that one hectare of intercropping gave 1.5 hectares of sole crop yield or 50 percent yield increase over sole cropping.

It was observed that this index failed to measure the competitiveness of component crops in intercropping systems. Intercropping mixtures with components that showed different competitive abilities can give the same LER value in intercropping systems.

For example, an LER of 1.5 can be obtained from the following intercrop relative yields;
0.5 + 1.0 = 1.5
0.6 + 0.9 = 1.5
0.7 + 0.8 = 1.5
The LER therefore failed to show the differences in competition between the crops in the three mixtures above.

Land Equivalent Coefficient (LEC): By taking a product of the relative yields the mixture in which one component showed the most aggressiveness gave least value while the mixture in which competition was least gave the highest value thus.
0.5 x 1.0 = 0.50
0.6 x 0.9 = 0.54
0.7 x 0.8 = 0.56

The third mixture with a value of 0.56 would be the best of the three above because it showed the least competition. The product of components relative yields, was called the Land Equivalent Coefficient (LEC) (Adetiloye *et al*., 1983). The LEC therefore can measure the competitiveness of the components. Crop mixtures with the lowest competition between or among the component crops will give highest LEC. The range of LEC values for a mixture of two crops is presented in Table 8. Intercropping mixtures with LEC values below 0.25 are not more productive than sole crops.

Table 8: Land equivalent coefficient (LEC) range where land equivalent ratio (LER) decreases as the land equivalent ratio of component crop "b* (Lb) increases

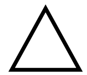
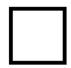
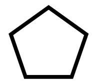
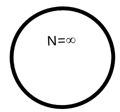
	LER of crop "b" (Lb)									
LER of crop "a" (La)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
1.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00
0.90	0.09	0.18	0.27	0.36	0.45	0.54	0.63	0.72	0.81	
0.80	0.08	0.16	0.24	0.32	0.40	0.48	0.56	0.64		
0.70	0.07	0.14	0.21	0.28	0.35	0.42	0.49			
0.60	0.06	0.12	0.18	0.24	0.30	0.36				
0.50	0.05	0.10	0.15	0.20	0.25					
0.40	0.04	0.08	0.12	0.16						
0.30	0.03	0.06	0.09							
0.20	0.02	0.04								
0.10	0.01									

Note; mixtures showing yiled advantages (LEC>0.25) are demarcated from unproductive mixture (LEC≤0.25).
Source: Adetiloye *et. al.,* (1983)

While the LER favoured the dominant component in the evaluation of mixture productivity, the LEC favoured the dominated component in the evaluation of mixture productivity. The LEC therefore agrees more than the LER with system's theory which says that the productivity of a system is determined by the factor or component that exhibits lowest performance.

Since both indices are correct in terms of their interpretations and because correlations between both values were often negative, I intuitively reconciled both indices geometrically (Table 9) to reflect the fact that both evaluated different perspectives (the additive and the multiplicative values of component relative yields) in the evaluation of the productivity of intercropping systems (Adetiloye et al 1983). The LEC is now used world-wide along with the LER in intercropping research for determining the competitiveness of component crops in intercropping and the productivity of intercropping systems.

Table 9: Symmetrical proportions in crop mixtures

Crops in a Mixture	Expected mixture proportions					Maximum number of mixtures	Minimum Productivity coefficient	Maximum Productivity coefficient	Geometric model
	P_1	P_2	P_3	P_4	P_5				
2	1/2	1	-	-	-	2^2	$(1/2)^2$	$(2/2)^2$	
3	1/3	2/3	1	-	-	3^2	$(1/3)^2$	$(3/3)^2$	
4	1/4	2/4	3/4	1	-	4^2	$(1/4)^2$	$(4/4)^2$	
5	1/5	2/5	3/5	4/5	4/5	5^2	$(1/5)^2$	$(5/5)^2$	
N	1/N	-	-	-	N/N	N^N	$(1/N)^N$	$(N/N)^N$	

Source: Adetiloye et al., (1983); Adetiloye (1985A)

3.2.2 Choice of Mixture proportions

It was observed also that intercropping experiments were carried out with the relative populations of components chosen haphazardly. This made it difficult to compute the competitive effect of the components on one another. It also made it impossible to compute the competitive effects of component crops on the productivity of intercropping systems. Mathematical proportions of crop components from the equivalent of sole crop population to the theoretical maximum of N optimum populations for N number of crops in in intercropping mixtures were then formulated. The mathematically formulated proportions covered two to infinite number of crops in mixture are shown in Table 10(Adetiloye, 1985a). This mathematical model placed the formulation of crop mixtures in intercropping systems in an elegant mathematical format in which the effect of components and their interactions can be computed easily.

3.2.3 Evaluation of Economic Advantage

The index for evaluating the superiority of intercropping systems over sole crops during my PhD research could only evaluate agronomic yield superiority or yield advantage of intercropping over sole cropping. Such yield advantage did not guarantee economic superiority of intercropping systems over sole crops. An economic index called the Monetary Equivalent Ratio (MER) was therefore formulated to determine the supe-

Table 10: Ideal and practicable distributions of mixture proportions for inter cropping systems' design

No. of mixture components	Expected mixture proportions					Max. number of combination of pro-portions	No. of mix-tures	Practicable proportions for inter-cropping	No. of mixtures
	P_1	P_2	P_3	P_4	P_5				
2	$^1/_2$	1	-	-	-	$(P_1+P_2)^2$	4	$(P_1+P_2)^2$	4
3	$^1/_3$	$^2/_3$	1	-	-	$(P_1+P_2+P_3)^3$	27	$(P_1+P_2)^3$	8
4	$^1/_4$	$^2/_4$	$^3/_4$	1	-	$(P_1+P_2+P_2+P_4)^4$	256	$(P_1+P_2)^4$	16
5	$^1/_5$	$^2/_5$	$^3/_5$	$^4/_5$	1	$(P_1+P_2+P_3+P_4+P_5)^5$	3125	$(P_1+P_2)^5$	32
N	$^1/_N$	…			$^1/_N$	$(P_1+P_2\ldots P_N)^N$	N^N	$(P_1+P_2)^N$	2^N
						$\boxed{\sum_{i_1=1}^{N}\sum_{i_2=1}^{N}\cdots\sum_{i_N=1}^{N}P_{i_1}P_{i_2}\cdots P_{i_N}}$		$\boxed{\sum_{i_1=1}^{n}\sum_{i_2=1}^{n}P_{i_1}P_{i_2}}$ or $\boxed{\sum_{k=0}^{n}\binom{n}{k}P_1^{k}P_2^{n-k}}$	

Source: Adetiloye (1985a)

riority or otherwise of an intercropping system over the sole crop that commanded the highest monetary value (Adetiloye and Adekunle, 1989).

Monetary Equivalent Ratio (MER) is computed as: $ra/Ra + rb/Ra$
Where “ra and rb” represent the monetary value of intercrops “a and b” while Ra represents the monetary value of the sole crop that commands the higher monetary value on the same unit area of land occupied by both intercrops.

An MER value of 1.5 shows that the monetary returns from intercropping is 50% higher the monetary return from the sole crop that gave the highest monetary return from the same unit are of land planted to intercrops.

The MER is now used world-wide in intercropping research for determining the economic advantage of intercropping over sole cropping.

3.3.0 RESEARCH ON VARIOUS INTERCROPPING SYSTEMS

The Problem: Farmers plant crops in mixtures in a rather haphazard manner, without a scientific understanding of how crops interact and compete for growth resources. Hence competition can exceed complementarity. My research in cropping systems focused on understanding the extent of competition, and how to reduce competition and thereby enhance how the crops can complement each other in exploiting space, soil moisture, light and nutrients.

3.3.1 Maize-Cowpea Intercropping Experiments -I

At the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, research was conducted from 1977 to 1980 on how to optimize the productivity of cowpea/maize intercropping.

Maize was planted at 15,000, 30,000 and 45,000 plants per hectare at zero, 45 and 90 kg of Nitrogen per hectare with two cowpea cultivars planted at 55,000 plants per hectare. The cowpea cultivars were VITA-1 (bushy type) and VITA-5 (spreading type). The cowpea varieties were planted within the rows of maize. The distance of maize to cowpea rows was 50cm.

Results and Recommendation: The results showed that maize shading increased as maize population increased. Growth and yield of cowpea reduced as maize population increased. The best mixture was cowpea planted at a plant population of 55,000 plants ha^{-1} with 30,000 plants ha^{-1} of maize in wet periods and with 15,000 plants ha-1 of maize in the dry season as shown in Table 11 (Adetiloye, 1980; Adetiloye et al. 1983).

3.3.2 Maize-Cowpea Intercropping Experiments -II

At Obafemi Awolowo University (OAU) Teaching and Research Farm, maize and cowpea were intercropped in alternate one meter single rows and alternate double rows at 50:50; 100:50; 50:100; 100:100 percent of sole crop populations, using my model for formulating mixture proportions. The distance between maize rows and cowpea rows was 100cm. Maize and cowpea were planted at one meter row spacing.

The result showed that Ife brown cowpea performed better when intercropped with maize in alternate double rows than in alternate single rows. The best cowpea yield was obtained when 50% of sole maize population was intercropped with 100 % sole cowpea population in alternate double rows (Table 12).

Table 11: Effect of maize plant population, cowpea varieties and nitrogen levels on land equivalent ratios and land equivalent coefficients values at Ibadan in 1977 late cropping season

Maize density Plants/ha	Nitrogen Kg/ha	Land Equivalent Ratio						Land Equivalent Coefficient (LEC=La x Lb)	
		Cowpea (La)		Maize (Lb)		Mixture (LER=La=Lb)			
		VITA-1	VITA-5	VITA-1	VITA-5	VITA-1	VITA-5	VITA-1	VITA-5
0	0	0.88	0.91						
	45	0.94	0.96						
	90	1.00	1.00						
15,000	0	0.59	0.61	0.34	0.34	0.93	0.95	0.20	0.21
	45	0.64	0.64	0.40	0.39	1.04	1.03	0.26	0.25
	90	0.63	0.61	0.46	0.44	1.09	1.05	0.29	0.27
30,000	0	0.40	0.42	0.59	0.64	0.99	1.06	0.24	0.27
	45	0.37	0.40	0.67	0.69	1.04	1.09	0.25	0.28
	90	0.37	0.39	0.82	0.77	1.19	1.16	0.30	0.30
45,000	0	0.28	0.35	0.73	0.77	1.01	1.12	0.20	0.27
	45	0.26	0.33	0.88	0.86	1.14	1.19	0.23	0.28
	90	0.23	0.33	0.96	1.00	1.19	1.33	0.22	0.33

1: LER > 1 showed higher yielding by the mixture
2: < 0.25 showed positive inter-stand interaction and higher yielding by mixture
3:
Source: Adetiloye (1980)

Table 12: Effects of mixture plant population and cropping pattern on seed yield of cowpea and grain yield of maize in two cropping season

Intercrop Proportion			Early Cropping Season			Late Cropping season	
	Cowpea	Maize	Maize grain yield (g/20m²)		Cowpea seed yield (g/20m²)	Maize grain yield (g/20m²)	Cowpea seed yield (g/20m²)
			P_1	P_2			
a_1b_1	$^1/_2$	$^1/_2$	4674	4850	921	3150	815
a_2b_1	1	$^1/_2$	4928	5381	975	2819	884
	$^1/_2$	1	6331	5899	731	2556	627
	1	1	6089	5698	747	2396	550
	S.E		152			73	16
Cowpea Effect A			12	330	70	-491	-8
Maize Effect B			2818	1366	-418	-1017	-522
AB Interaction			496	731	-38	171	-146
Cropping Pattern							
P_1			-		780	2792	659
P_2			-		910	2669	780
S. E.			-		11	20	12
Sole Crop (20m²)			7475		1782	4316	1665

Source: Adetiloye (1986)

The various maize and cowpea intercropping experiments did not give very high yield superiority over sole crops of maize or cowpea because the taller maize crop caused severe shading of cowpea, more so when both crops grow and mature about the same time.

Attempts were therefore made to explore other mechanisms of manipulating for higher productivity in intercropping systems by increasing the number of crops in intercropping to three or four crops.

Attempts were also made to find out if intercropping yield and economic advantages could be enhanced by intercropping cassava with plantain. Plantain is normally planted at much wider spacing than cassava which matures for harvesting before plantain.

3.3.3 Cassava + Maize + Cowpea Intercropping and Cassava + Maize + Cowpea + Okra Intercropping

At Obafemi Awolowo University Teaching and Research Farm, studies were carried out to find out if increase in the number of crops and therefore the diversity of crops in intercropping systems confer more yield advantage over sole crops. Secondly, we wanted to find out if the advantage of yield increase in intercropping over sole cropping translated to more economic advantage over sole crop.

Results and Recommendations: Table 13 showed that cassava/maize/cowpea intercropping gave agronomic yield advantage of 12 to 63% over sole crop. Monetary advantage was barely 6-14% better than that of the most profitable sole crop.

Mixture of cassava/maize/cowpea/okra gave agronomic yield advantage 2-25% over sole crop. Monetary return from the mixture of four crops was just 50 to 62% of the monetary return for the most profitable sole crop (Table 14).

Evaluation of agronomic and economic advantages of intercropping systems showed that higher agronomic advantage did not translate to higher economic advantage in intercropping over sole cropping where crops that command low economic value are substituted for crops with higher economic values.

Intercropping systems can provide both higher yield (agronomic advantage) and higher monetary return (economic advantage) over sole cropping only when crops that command high monetary values are planted at optimum population while crops with lower economic values are planted as minor crops in intercropping systems.

Table 13: A comparison of yield advantages indicated by Land Equivalent Ratio (LER) and Monetary Equivalent Ratio (MER) values of crop components and mixture of various intercrop and mixture of plant population densities in a Cassava-Maize-Cowpea Intercropping.

Plant Population Proportion			Land Equivalent Ratio (LER)				Monetary Equivalent Ratio (MER)			
Cassava	Maize	Cowpea	Cassava	Maize	Cowpea	Mixture	Cassava (ra/Ra)	Maize (rb/Ra)	Cowpea (rc/Ra)	Mixture
1/3	1/3	1/3	0.72	0.52	0.22	1.29	0.72	0.28	0.12	1.06
1/3	1/3	2/3	0.74	0.60	0.30	1.63	0.74	0.32	0.16	1.14
1/3	2/3	1/3	0.58	0.47	0.20	1.30	0.58	0.25	0.11	0.88
1/3	2/3	2/3	0.52	0.42	0.22	1.16	0.60	0.23	0.12	0.89
2/3	1/3	1/3	0.78	0.47	0.20	1.33	0.78	0.25	0.11	1.08
2/3	1/3	2/3	0.79	0.47	0.27	1.32	0.79	0.25	0.11	1.10
2/3	2/3	1/3	0.63	0.39	.16+	1.17	0.63	0.18	0.08	0.85
2/3	2/3	2/3	0.64	0.40	0.18	1.12	0.64	0.21	0.10	0.90
S.E			±0.27	±0.02	±0.02	±0.05	±0.0.03	±0.021	±0.004	±0.04
Sole crop			1.00	1.00	1.00	1.00	0.53	0.54	0.05	1.00

Mixture MER = (ra+rb+rc)/Ra
Source: Adetiloye and Adekunle, 1989

Table 14: A comparison of yield advantages indicated by land equivalent ratio (LER) and monetary equivalent ratio (MER) values of crop components and mixture of various intercrop and mixture of plant population densities in a cassava-okra-maize-cowpea intercropping

Plant Population Proportion				Land Equivalent Ratio (LER)					Monetary Equivalent Ratio (MER)				
Cassava	Okra	Maize	Cowpea	Cassava	Okra	Maize	Cowpea	Mixture	Cassava (ra/Ra)	Okra (rb/Ra)	Maize (rc/Ra)	Cowpea (rd/Ra)	Mixture
1/4	1/4	1/4	1/4	0.27	0.25	0.24	0.26	1.02	1.02	0.06	0.09	0.08	0.50
1/4	1/4	1/4	1/2	0.27	0.26	0.24	0.27	1.04	1.04	0.06	0.09	0.08	0.51
1/4	1/4	1/2	1/4	0.30	0.26	0.35	0.24	1.15	1.15	0.06	0.13	0.07	0.58
1/4	1/4	1/2	1/2	0.27	0.26	0.36	0.26	1.15	1.15	0.06	0.13	0.08	0.56
1/4	1/2	1/4	1/4	0.28	0.33	0.22	0.24	1.07	1.07	0.08	0.08	0.07	0.52
1/4	1/2	1/4	1/2	0.29	0.36	0.24	0.25	1.14	1.14	0.09	0.09	0.07	0.53
1/4	1/2	1/2	1/4	0.28	0.35	0.35	0.26	1.24	1.24	0.09	0.13	0.07	0.59
1/4	1/2	1/2	1/2	0.27	0.35	0.34	0.26	1.22	1.22	0.07	0.12	0.08	0.57
1/2	1/4	1/4	1/4	0.36	0.27	0.25	0.25	1.13	1.13	0.07	0.09	0.07	0.61
1/2	1/4	1/4	1/2	0.33	0.30	0.25	0.25	1.13	1.13	0.06	0.09	0.07	0.58
1/2	1/4	1/2	1/4	0.34	0.26	0.34	0.23	1.17	1.17	0.07	0.13	0.07	0.62
1/2	1/4	1/2	1/2	0.33	0.29	0.33	0.24	1.19	1.19	0.09	0.12	0.07	0.61
1/2	1/2	1/4	1/4	0.34	0.35	0.23	0.26	1.18	1.18	0.09	0.09	0.08	0.61
1/2	1/2	1/4	1/2	0.34	0.35	0.26	0.25	1.20	1.20	0.08	0.09	0.07	0.61
1/2	1/2	1/2	1/4	0.30	0.33	0.36	0.24	1.23	1.23	0.08	0.13	0.07	0.61
1/2	1/2	1/2	1/2	0.31	0.34	0.37	0.23	1.25	1.25	0.08	0.14	0.07	0.62
S.E.				±0.08	±0.0 1	±0.01	±0.003	±0.02	±0.008	±0.008	±.006	±0.002	±.01
Sole Crop				1.00	1.00	1.00	1.00	1.00	1.00	0.25	0.44	0.29	1.00

Source: Adetiloye and Adekunle, 1989

3.3.4 Plantain plus Cassava Intercropping

Plantain is usually planted at 3m x 3m spacing and it takes about 15 months from planting to harvesting. Cassava takes 6 – 12 months from planting to harvesting depending on the variety and location. It is normally planted at 1m x 1m spacing in South Western Nigeria. Attempt was therefore made to compress cassava stands into the spaces within plantain rows in order to evaluate their compatibility and therefore their agronomic and economic advantages.

Results and Recommendations: The early maturing cassava variety used (TMS 4 (2) 1425) released by IITA was able to reach harvestable yield at 6 to 9 months after planting well before shading by plantain could substantially reduce the yield potential of cassava. The results presented in Table 15 showed that this system gave very high agronomic yield advantage of 62% over sole crop and 65% higher economic advantage (Adetiloye, 2005).

Optimum sole crop population of plantain and optimum sole crop population of early maturing and non-aggressive cassava genotype can be successfully intercropped such that one hectare of plantain and cassava intercropping will contain the optimum sole crop populations of both crops, which gives twice the normal population of sole crops per hectare. This was the first instance in which I obtained high complementary yielding and high economic advantage in my intercropping studies.

Table 15: Effect of mixture plant population on harvestable yield of cassava and plantain and intercropping advantage

			Monetary Equivalent Ratio			Land Equivalent Ratio			Land Equivalent Coefficient
Treatment	Cassava Yield t/ha	Plantain Yield t/ha	Cassava	Plantain	Mixture	Cassava	Plantain	Mixture	
a1b1	24.41	8.00	0.60	0.66	1.27	0.63	0.66	1.29	0.41
a1b2	32.86	7.98	0.81	0.66	1.47	0.84	0.66	1.51	0.56
a2b1	24.14	10.83	0.60	0.90	1.50	0.62	0.90	1.52	0.56
a2b2	29.90	10.63	0.74	0.88	1.62	0.77	0.88	1.65	0.65
LSD, 5%	9.60	1.59	0.25	0.42	0.33	0.24	0.25	0.34	0.20
Plantain Effect (A)	-1.62	2.73	-0.04	0.23	0.19	-0.04	0.23	0.19	0.14
Cassava Effect (B)	-7.10	-0.13	0.17	-0.01	0.16	0.18	-0.01	0.17	0.13
Interaction	-1.34	-0.07	-0.03	-0.01	-0.04	-0.03	-0.01	-0.04	-0.01
Sole Crop	38.84	12.08	0.96	1.00	1.00	1.00	1.00	1.00	0.25

Sole crop Monetary value (N ha^{-1}) = 11651 One tonnes of Cassava at N30000
One Dollar = 110 naira 12077 One tonnes of Plantain at N10, 000

Source: Adetiloye, 2005

Similar results were obtained with intercropping of Oil Palm and other arable crops here at FUNAAB. Intercropping of arable crops with Oil Palm (Tables 16 and 17) was able to off-set most of the cost of establishment and maintenance of oil palm plantation in the first three years after planting (Fabunmi, *et al.*, 2005).

3.3.5 Research on yield stability in different Cropping Systems

Research on the stability of cropping systems was undertaken on incidence of stem borers on late season maize (Adetiloye *et al*, 2002). Four cropping systems were evaluated; Early season sole cowpea followed by late season maize; early season sole maize followed by late season sole maize; early season cowpea/maize intercropping followed by late season cowpea/maize intercropping in which both crops were planted on the same rows in the early and late season; early season cowpea/maize intercropping followed by late season cowpea/maize intercropping in which the rows of both crops were interchanged during the late season. The best cropping system was early season sole cowpea followed by late season sole maize. Early season maize followed by late season maize gave the poorest maize yield. Late season cowpea/maize intercropping in which the rows were interchanged was second best and was better that cowpea/maize intercropping in which the crop rows were not interchanged in the late season (Table 18).

Table 16: Annual Monetary Return on Food Crops (Maize, Soybean and Pigeon pea)

Crop Mixtures	Mixture Monetary Returns (N / Ha)			
	1999	2000	2001	SUM
Oil Palm/Maize/Soybean/Pigeon pea +Fertilizer	76,676	5,559	71,263	153,498
Oil Palm/Maize/Pigeon pea + Fertilizer	60,144	2,288	73,135	135,567
Oil Palm/Maize/Soybean + fertilizer	71,581	9,575	71,393	152,549
Oil Palm/Maize + fertilizer	40,945	-	46,000	80,945
Oil Palm/Maize/Soybean/Pigeon pea +Fertilizer	57,414	5,651	23,035	86,100
Oil Palm/Maize/Pigeon pea + Fertilizer	36,652	2,700	38,877	73,229
Oil Palm/Maize/Soybean + fertilizer	45,673	6,266	18,016	69,955
Oil Palm/Maize + fertilizer	14,992	-	16,000	30,992

Fabunmi *et al.*, 2005

Table 17: Production Cost, Total Revenue and Net Revenue for Three (3) Years

Crop Mixtures	(a) Total Revenue Estimates From Food Crops (N)	(b) Established Cost Oil Palm (N)	(c) Total Annual Recurrent Cost on Food Crops (N)	Net Return (N) (a)-(b+c)
Oil Palm/Maize/Soybean/ Pigeon pea +Fertilizer	153,498	27,260	159,150	-32,912
Oil Palm/Maize/Pigeon pea + Fertilizer	135,567	27,260	142,650	-34,234
Oil Palm/Maize/Soybean + fertilizer	152, 549	27,260	140,250	-15,039
Oil Palm/Maize + fertilizer	80,945	27,260	123,750	-70,065
Oil Palm/Maize/Soybean/ Pigeon pea +Fertilizer	86,100	27,260	132,150	-74,310
Oil Palm/Maize/Pigeon pea + Fertilizer	73,229	27,260	115,650	-69,681
Oil Palm/Maize/Soybean + fertilizer	69,955	27,260	114,250	-71,555
Oil Palm/Maize + fertilizer	30,992	27,260	96,750	-93,018

Fabunmi *et al.*, 2005

Table 18: Late season maize yield of grain, cob length and test seed weight and cowpea yield in the late season

	Maize grain (ton/ha)	Cob Length (cm)	100 maize seeds weight (g)	Cowpea grain (ton/ha)	100 cowpea seeds weight (g)
Sole maize crop after first season sole cowpea	1.15a	15.8a	25.7a	-	-
Maize-cowpea rotational strip intercropping in the second season	0.75b	14.1ab	23.5a	0.52a	12.9aa
Maize-cowpea continuous strip intercropping in the second season	0.37bc	12.7ab	22.1a	0.44a	12.7
Sole maize crop after first season sole maize plot	0.30bc	11.5b	21.0a	-	-
LSD	0.78	3.55	4.96(n.s)	0.45(n.s)	1.118(n.s)

4.0 INTERCROPPING SYSTEMS PHILOSOPHY

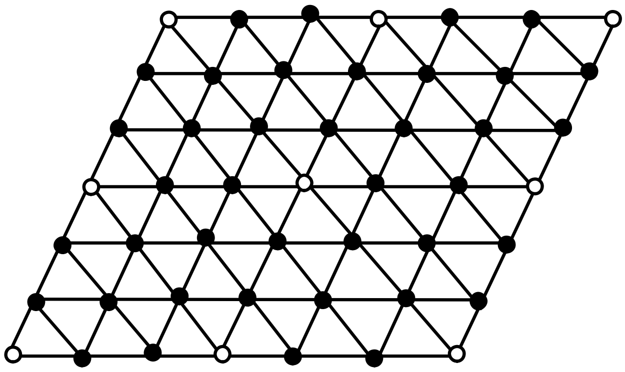
The arrangement of crops in sole cropping is such that at maturity the canopies of the crops should touch at optimum plant population. Where a slow growing crop like plantain and oil palm that takes a long time to close canopies is planted, another crop species such as cassava, or maize or cowpea with a shorter maturity period can be planted between the stands of the slow maturing crop to enhance the use of growth resources (light, moisture, nutrients etc.). Their possible geometric configurations in space (Figure 3) and time (Figure 4) is essentially a topological problem of close packing to optimize the use of land, space and other resources available for crop growth.

The ideal intercropping situation illustrated in Figure 5 is one in which the canopies of the component crops will exhibit no competition but complement in sharing space and growth resources when the least competitive or minor crop is mature for harvest. This multi-story intercropping is prevalent among resource-poor farmers in Africa.

5.0 RECOMMENDATIONS ON INTERCROPPING SYSTEMS

Various factors affect the choice of crops that are grown together in intercropping systems. Intercrops must be compatible in the sense that they must exhibit minimal competition and maximum complementation. This is the ability of two or

Triangular planning pattern in a mixture of two crops
○ Crop A–3 x 3m spacing
● Crop B–1 1m spacing



Rectangular planning pattern in a mixture of two crops

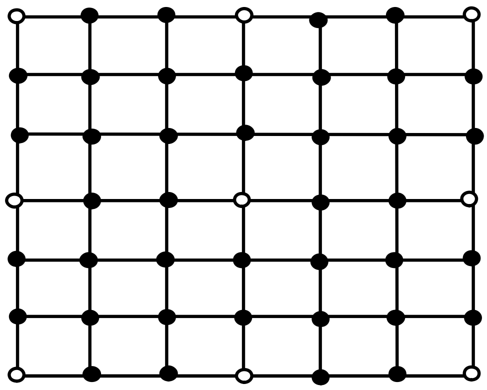
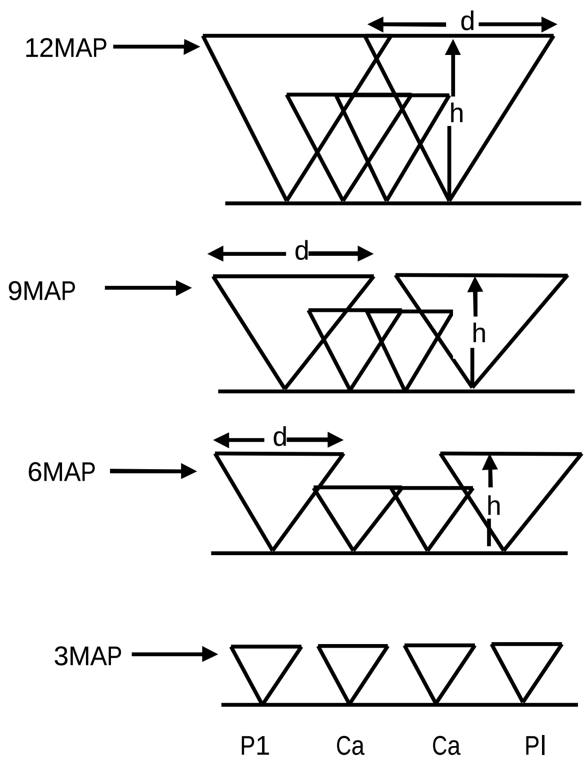


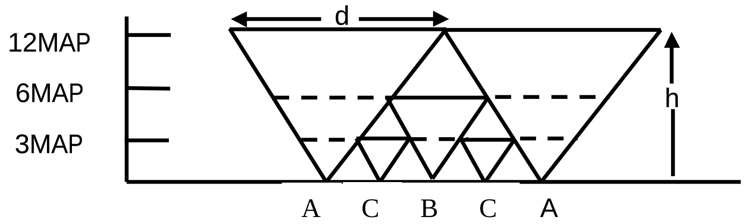
Figure 3: Triangular and rectangular planting patterns in intercropping system (Source Adetiloye 1996)



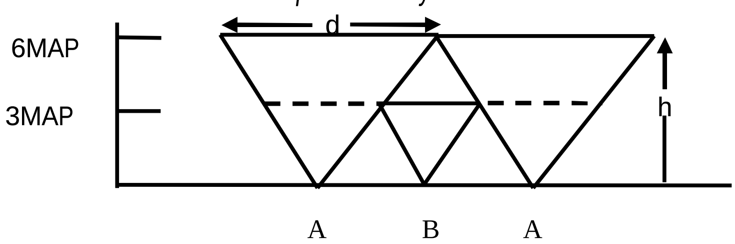
KEY

h: Plant height of plantain or cassava
d: Canopy spread (diameter) of intercrop
P1: L Plantain planted at 1m x 1m spacing
Ca: Cassava planted at 1m x 1m spacing
MAP: Months after planting

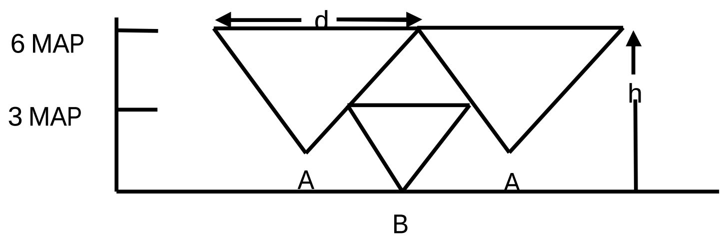
Figure 4: Canopy configuration in plantain-cassava mixture
Source: Adetiloye (1996)



A three crop multi-story association



A double-story crops association



A Relay intercropping system

KEY

h: Plant height of intercrop
d. Canopy diameter of intercrop
A: Crop A at widest spacing attains maximum canopy size at 12 MAP
B: Crop B at medium spacing attains maximum canopy size at 6 MAP
C: Crop C at smallest spacing attains maximum canopy size at 3 MAP
MAP: Months after planting

Figure 5: Ideal canopy configuration in intercropping (Source: Adetiloye, 1996)

more crops to grow together on the same piece of land for a reasonable period of time without serious competition for space, soil moisture, soil nutrient and light.

My research works showed that high agronomic yield advantage and high economic advantage in intercropping relative to sole cropping can be achieved by manipulating the following:

- Selection of compatible crops
- Choice of suitable proportions of component crops by increasing the proportion of the shorter (dominated) crop and reducing the proportion of the taller (dominant) crop.
- By intercropping the dominated crop and the dominant crop in different strips to minimize competition
- By planting a semi-perennial crop such as plantain or a perennial crop such as oil palm that has low plant population density per hectare and therefore takes longer time to mature with arable crops that are planted at high plant population but take shorter time to mature.

Diversity of crops in intercropping systems can enhance overall crop yield and keep farmers busy all year round. More crops also provide a variety of foods for the farm family.

Diversity of crops in intercropping systems will give higher economic advantage only where the most profitable crop is the major or priority crop, while crops of low economic value should be the minor crop.

6.0 FROM GRASS TO GRACE

I suddenly and intuitively realized in the course of my research that the 2-D models earlier presented in Table 9 for evaluating the productivity of two to theoretically infinite number of crop mixtures (Adetiloye 1985a) would fit into systems theory in all disciplines in which the human mind seeks to unravel the mathematics of simple to complex systems.

Intercropping involves close packing of different crop canopies. Ideal close packing is found in the evolution of simple to complex 3-dimensional spaces as shown in Figure 6 (Adetiloye 1985b). I also designed more advance close-packing topologies or hyperspaces which my undergraduate and post graduate students used to investigate their energizing the effect on seed vigour, crop growth and yields.

Crop Circles-Mathematics on Crops Fields

The mathematics of close packing of topological spaces had been advanced to higher levels by extinct civilizations that existed millions of years ago as seen from hundreds crop circles My hyperspace design are found in the two dimensional sym-

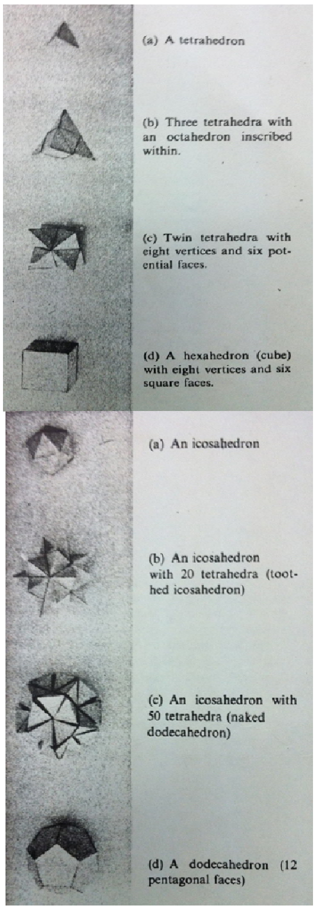


Figure 6: Evolutionary sequence of three-dimension solids

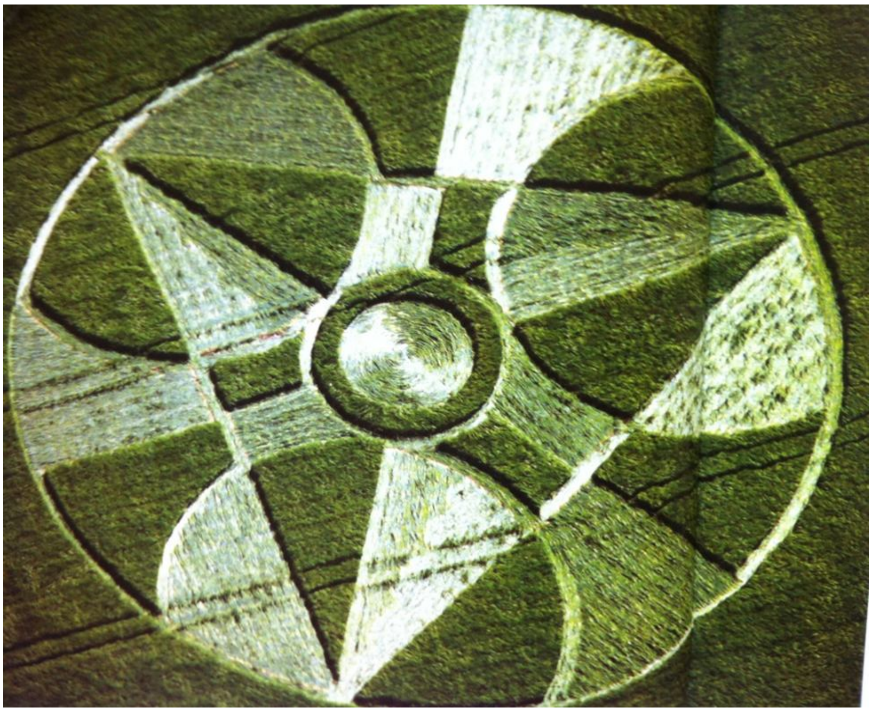
Source: Adetiloye (1985b)

that mysteriously appear on crop fields in UK annually every summer. Scientists in Europe, Canada and USA had tried in vain to unravel the origin of crop circles. Crop and soils samples from crop circle sites have been analyzed in University laboratories in UK. Crop circles on crop fields lead to huge annual yield and financial losses to farmers in UK. Up to 40% yield increase occur the year that follows on previous crop circle size due to the residual beneficial effect of high electromagnetic field left by crop circles on the soil.

A few of the hundreds of crop circles that appear on farmers' fields in UK and some European countries each summer is shown in Appendices I, II, III and IV.

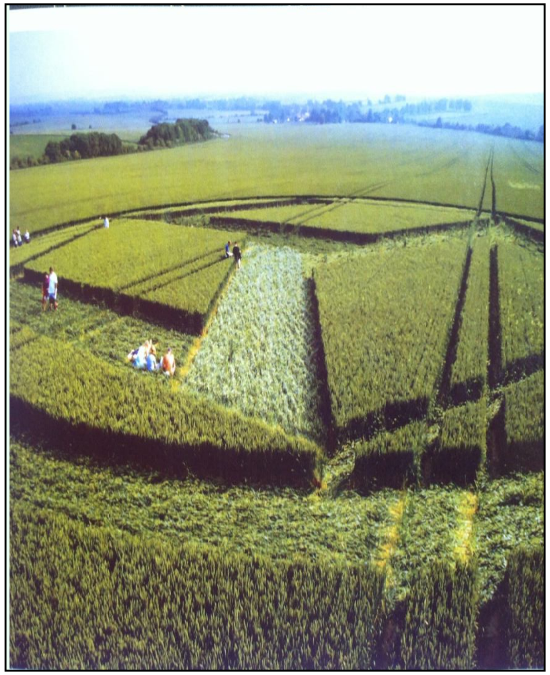
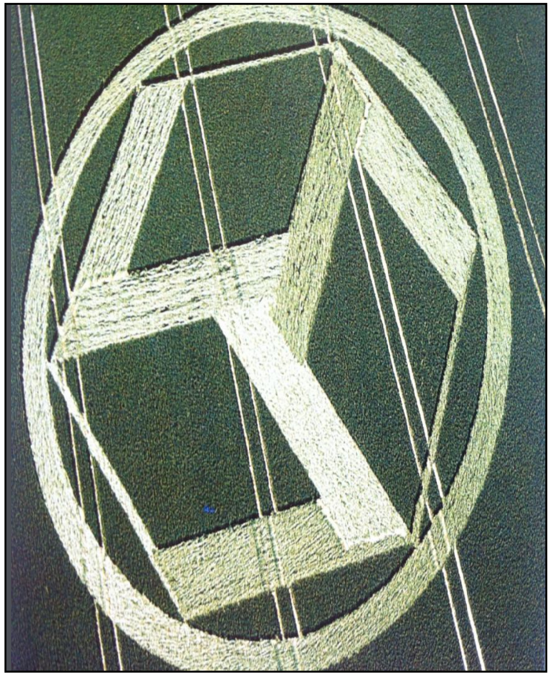
What is ingenious about the crops circles is how the great minds that engineered them were able to compress different regular hyperspaces together within the spherical shape of the Moon, just as Johaness Kepler (1617) compressed the five regular solids together in his *Harmonies Mundi* (Appendix V). Three of my hyperspaces that are currently being investigated for seed energizing technique in this university are similar to the two dimensional projections contained in crop circle patterns.

Appendix I: Pyramidal pattern in crop circle



Source: Steve and Karen Alexander (2006)

Appendix II: A cuboid crop circle pattern inside wheat crop field

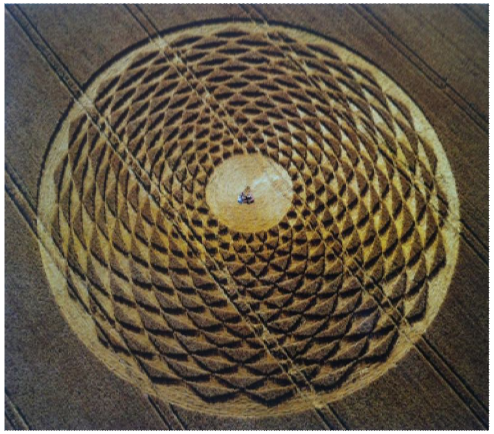
Wheat crop, approximately 200 feet. Allington Down, Wiltshire, England. June 1999.

Source: Steve and Karen Alexander (2006)

Appendix III: Crop circle pattern inside wheat crop field

Wheat Crop field, approximately 175 feet. Etchilhampton, Wilshire, England August 1997
Source: Steve and Karen Alexander (2006)

Appendix IV: Crop circle pattern inside barley crop field



Barley crop, approximately 350 feet. North Down, Wiltshire, England, July 2003
Source: Steve and Karen Alexander (2006)

metric pattern projected on crop fields as crop circle patterns.

I was the first scientist in the world to reveal in 2011 on the internet that crop circles are generated by the energy vortex of the Moon. I stated that the regular geometric patterns in crop circles are projections of the internal symmetry of the Moon on crop fields from different angles or perspectives. I stated further that the Moon must be a geometric hyperspace for it to be forming such regular geometric patterns on crop fields.

I sent a proposal to the Tech-Innovations Center in a University in California for a grant to support the commercialization of my seed energizing designs which are constructed from complex geometrical close packing designs (hyperspaces) for farmers use. The grant was not secured.

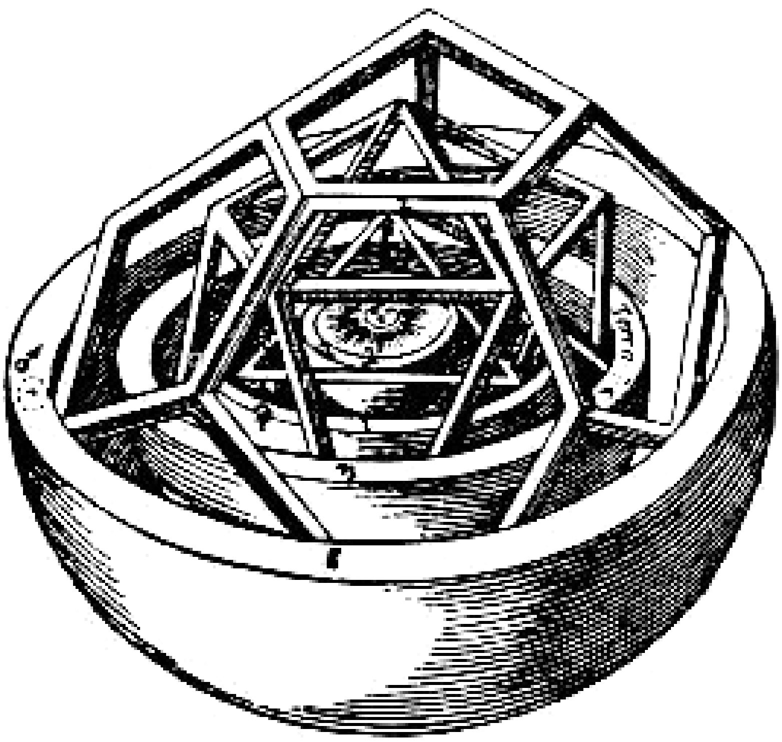
It is an interesting coincidence that a few months after that, NASA sent a rocket to the Moon to study how the energy of the Moon would affect the growth of seedling planted in growth chambers on the Moon.

The pictures sent by US Viking II from planet Mars (Adetiloye 1996) showed that Martian houses are built as hyperspace designs.

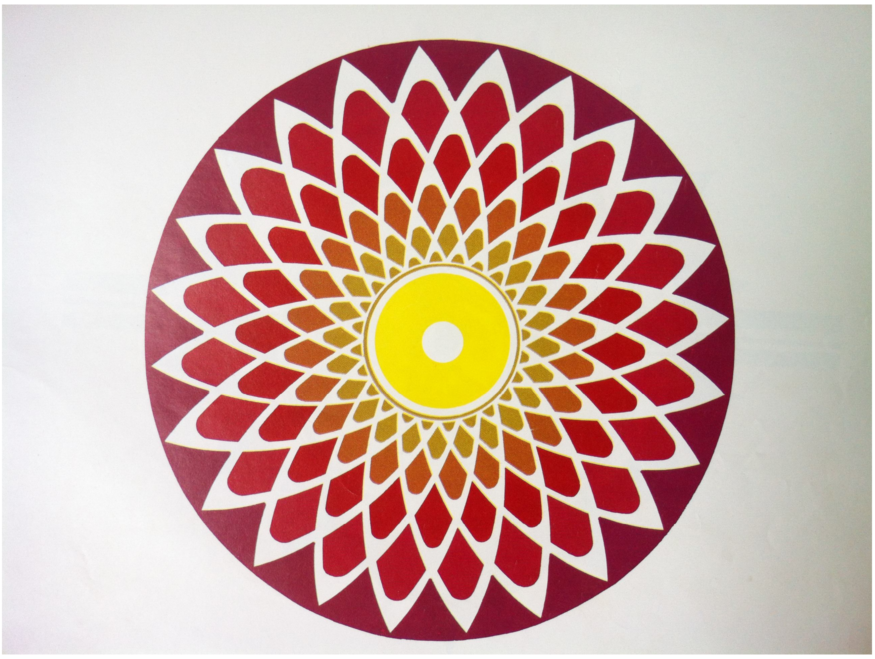
My mathematical descriptions of simple to complex intercropping systems had also been used in various world religions and mystical traditions to describe the evolution of human consciousness. Appendix VI looks like a crop circle pattern but is not. It is the symbolic representation of the highest level of human consciousness (Appendix VII) in the Indian Buddhist religion which dated to about 3000BC. A similar mathematical description of human consciousness has been in existent for thousands of years (Table 19) in the initiatory degrees of the mystery schools.

The association of entities is a common feature in nature; mixture of crops in intercropping, mixed species in natural ecologies, aggregation of elements in ligand complexes, crystal systems, and different combinations of DNA bases in molecular biology and interaction of subatomic particles in physics among others. The mathematical elucidation of simple to complex interactions among the components of such systems also follows similar pattern that conforms to Systems Theory.
In intercropping systems, the interaction of such crop components could be competitive, complementary, or synergistic depending on growth rates, populations or frequencies and ratios of relative abundance. The process of examining proportions and the nature of interactions in intercropping systems led me to discover the ideal and symmetric proportions for mixing crops and how to evaluate interactions with a bias to selecting mixtures with complementary and synergistic bene-

Appendix V: Johaness Kepler's *Harmomies mundi*

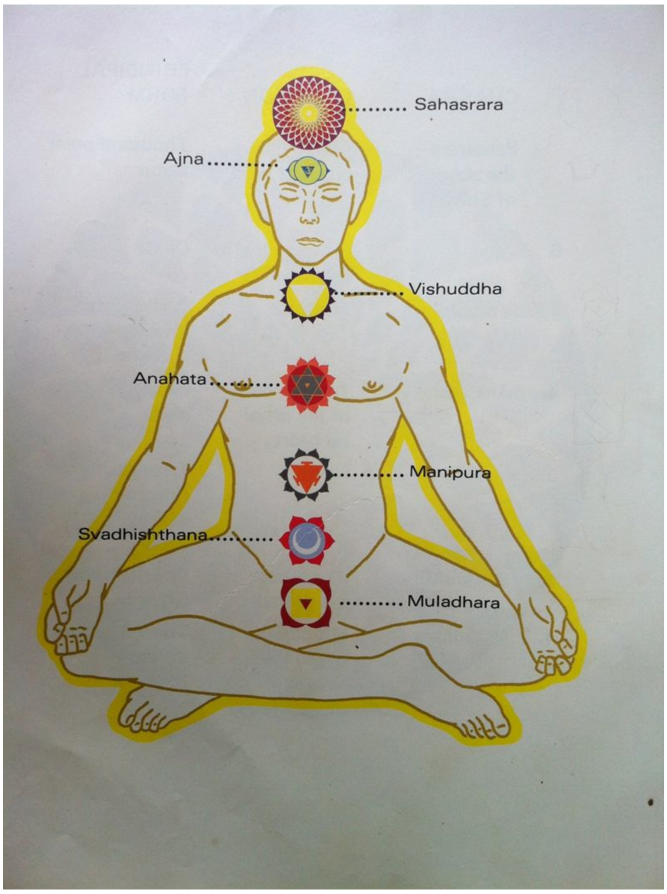


Appendix VI: Buddhist Thousand Petalled Lotus Yantra



Source: Hitleman, 1976

Appendix VII: The seven energy centers in Yoga Buddhism



Source: Hitleman, 1976

Table 19. Initial degree and associated meaning, Presiding God names, arch angels and geometry symbols

Degree	Sephira	Meaning	God Names	Archangel	Angel	Symbol
10=1 Ipsissmus	Kether	The ancient of days	Eheeih	Metatron	Chaoit a Quadesh	
9=2 Magus	Chokmah	Illumination, Enlightenment	Jehovah	Ratziel	Auphanims	
8=3 Magistal Tem-pli	Binah	Knowledge and Understanding	Jehovah Elo-hin	Tzaphkiel	Angels on the Throne	
7=4 Adeptus Ex-cemptus	Chesed	Devine Love and Mercy	El	Tzadkiel	Chasmalims	
6=5 Adeptus Major	Geburah	Righteousness	Elohim Ge-bor	Kamaliel	Seraphims	
5=6 Adepus Minus	Tipherath	Light of the Messiah	Jehovah Eloa Va Daat	Raphael	Melachisms	
4=7 Philoso-phus	Netsach	Victory	Jehovah Saboath	Haniel	Elohims	
3=8 Practicus	Hod	Glory Splendor	Elohim Saboath	Micahael	Beni Elohim	
2=8 Theoricus	Yesod	The Holy Spirit	Chadai El Chadai	Gabriel	Cherub	
1=10 Zealator	Malkuth	Earth, Physical Universe	Adonai	San-dalphon	Ashims	

fits. The language of nature in balanced symmetries is obviously one of complementarily, and not competition.

Suddenly my ideal proportions translated to ideal symmetries which I now see everywhere in nature. My enunciations on intercropping systems for complementary yielding, becomes a simple manipulation of mathematical variants; proportions of crops in space, time and symmetry. These symmetries unfold the divine mathematics in creation. Thus Pythagoras asserted; "In the beginning, God geometrized".

Hardly did I envisage when I started to unravel the mathematics of complex intercropping systems that my inspirations over years of sleepless nights would lead me to unpremeditated journey from "Grass to Grace" during which I discovered the same mathematics that had been used in various ancient religions and the same technologies that had been developed over millions of years on another planet.

7.0 FUTURE RESEARCH DIRECTIONS

The highest degree in the University is called Doctor of Philosophy, PhD in short. Where scientists engage in years of research but fail to provide a holistic perspective of his or her findings as a Philosopher of Science, then it may be worth reconsidering his or her qualification as a Doctor of Science rather than a Doctor of Philosophy. Based on my years of research experience, my focus in the years ahead would be on the following:

1. Advisory Services on Cropping Systems: Advisory services on productive and sustainable cropping systems on small and large scale farming will be provided where and when needed to public and private initiatives.
2. Climate Change Research: It has been revealed from our analysis of climatic data over the various latitudes in Nigeria that climate change actually became noticeable from 1990s in Nigeria for all climatic data elements analyzed (rainfall, minimum and maximum temperature). The large variation continued to date. This sudden change in climate exhibits a distinct pattern and was more in the Northern States of Nigeria than in the southern region. Temperature rise of 9^0Cand 5^0C had been recorded in the North and South of Nigeria respectively, due to climate change. In Southern Nigeria, the pattern of variations appeared more diffuse. These two major findings confirm my earlier press conferences (2011 and 2014) that climate change is caused by aerial bombing wars which became conventional weapon of warfare from the 1990s to date. The high magnitude of climate change in Northern Nigeria could be explained by the fact the North is closer to the aerial bombing war zones in the Middle East. Africans suffer the effects of this climate change more than any continent. The

message to stop the use of aerial bombings during wars will continue in order to forestall further damages to agriculture, humans, animals and our environment.

3. Seed energizing technology invention for increasing the growth and yield of arable crops: The topological space enclosure that I invented from my mathematical close packing systems (Adetiloye 1985a) were used to energize seeds of cowpea, soyabean, maize and groundnuts. Results obtained from more than ten undergraduate research projects and a PhD research showed that growth and yield of tested crops were substantially enhanced by about 40% without additional costs. In the years ahead, efforts will be made to make this technology invention available to famers in Nigeria and elsewhere to boost crop yields notwithstanding the bottlenecks that confront innovators and inventors in higher institutions in Nigeria.
4. Space Research: The discoveries from my research on the mathematics of complex systems and its technological applications have been used to give far reaching advice on the direction of research on the Moon and outer space. Human research and activities in outer space will continue to be monitored to avoid human errors that could spell danger on Earth environment and on our civilization during outer space exploration and research. Further details on this thrust are contained in my book titled: *Humankind, religion, science and the future* (Adetiloye, 1996).

8.0 GENERAL RECOMMENDATIONS

1. I was able to achieve the desired level of concentration that resulted in my scientific discoveries because I did not have to worry about accommodation, food, transportation, water, and electricity and research facilities while doing my PhD research at IITA as a Ford Foundation Research Fellow. In Nigeria, students and lecturers work far below their full potentials with the appalling environment in our Universities where basic life support systems are not functioning properly. Government should ensure that the University environment is made conducive for learning research, innovativeness and inventions.
2. In a normal situation, the research findings from Universities should be made available through the extension arm of the University to government agricultural extension service which is presently anchored by the State Agricultural Development Programmes (ADPs) for evaluation and adoption by farmers. Unfortunately, University and extension linkage is still very poor in Nigeria, such that research finding from Universities are left to gather dust on book shelves. Thus government must ensure that the extension service is well managed to harness the enormous research innovations from our Universities.
3. In Nigeria, agriculture had received billions of naira budgets for decades. Yet our agriculture has not developed to

international standard because the approach of governments to agricultural development has not been quite right. This is mainly because agricultural development in Nigeria cannot perform better than the most limiting factor(s) within the agricultural system. We have the quantum of professional experts in all fields of agriculture in Nigeria that can transform our agriculture to an advanced level. But that can only be possible where the other factors that determine the performance of the Nigerian Agricultural system are not limiting. In reality, the other factors are seriously limiting. Where policies, programmes, support services, capital or credit are seriously limiting, agricultural research information alone cannot achieve the desired transformation of Agriculture in Nigeria. Government should work closely with Nigerian experts in our Universities to propel agricultural development in the right trajectory and to ensure that the limiting factors in our Agricultural System are remedied to facilitate the much desired development of agriculture in Nigeria.

4. Nigerian universities have woefully failed to harness inventions from our Universities for rapid industrialization of our country primarily because Universities in Nigeria were fashioned by the colonial masters to train manpower for the civil service and foreign companies. This pattern has not changed. Secondly, funding of research and innovations from research in Nigerian universities has remained

extremely poor for decades.

In Nigeria of today, the scarcity of government and corporate jobs has turned the easy access to higher education into major problem with the large number of unemployed graduates and the exodus of our best brains to greener pastures. Government should pump money for the development of innovations and inventions from University researches to fast track industrialization of Nigeria before seeking foreign investors that will come and transform Nigeria to an industrial country.

5. Government should listen to their experts on major international issues. Our research findings here confirm for instance that climate change is caused by aerial bombing wars and not by greenhouse gas emissions that western scientist claim to be the cause of climate change.

9.0 ACKNOWLEDGEMENTS

I thank my CREATOR, THE ALMIGHT LIVING GOD, THE ALPHA AND OMEGA, THE ANCIENT OF ANCIENTS, THE ANCIENT OF DAYS, THE CONCEALED OF THE CONCEALED, THE OMINIPOTENT AND OMINISCIENCE GOD, for sending me to this world.

I thank my GOD for His love and mercies; for His divine providence and for the meaningful coincidences that GOD arranged for me to meet the “human angels” who helped to

direct and shape my destiny.
I thank God of wisdom who illuminates and enlightens the human mind, for the inspirations that I received in my research discoveries and inventions.

I thank my parents; Pa and Mrs. Gabriel Akingbade Adetiloye (my first two Angels) through who I journeyed to this world. My Father thought me self-dependence through ones sweat and hard work, honesty and sincerity of purpose in ones pursuits and encounters. My mother was an epitome of love for his children and my father. She was caring, loving, beautiful and always working hard to support my father and her children. I pray that their souls will continue to abide in the highest realm of Light?

I sincerely thank my siblings;
Mrs. Elizabeth Ajayi, my eldest sister and my 3rd angel. She took delivery of our first son and second set of twins at State Hospital Akure where she was in charge of the Anti-natal Ward. She retired as a Matron at the State Teaching Hospital, Ado Ekiti. She is always there to take care of our malaria fevers whenever we were at home.

I sincerely appreciate my elder brother Mr. Dare Adetiloye, my 4th angel for being there for me while we were growing up and thereafter. He retired from public service as an accountant.

I sincerely appreciate my elder sister Mrs. Yemi Seriki, my 5th angel a Radiographer and a breast cancer specialist in UK for her concerns about my family and progress on my job.

I sincerely appreciate my younger sister, the last born in the family, Mrs. Ebun Toluwani, my 6th angel for her constant telephone calls.

I thank my School Principal (Senator P. A. Ogundipe, a native of Ijesa Isu Ekiti, my 7th Angel) at Ise Emure Grammar School. He knew every pupil by name and by face. He was our Latin teacher in Form two. He also knew I was often not in the class. He came to our family house one and advised my elder brother who had just finished from Notre Dame Grammar School Usi Ekiti to transfer me from his School to another school outside the town because the farm work was eating too much into my school time and affecting my academic performance. There and then my elder brother prepared an application for me to transfer to Notre Dame Grammar School where I spent another three years to complete my secondary school education.

Late Rev. Father Joseph Asanbe (my 8th Angel) was our Rev. Father in Notre Dame Grammar School, Usi Ekiti. I was one of the Altar boys who served the Rev. Father during Mass. While I was at Oyemakun Grammar School for my High

School, I went to visit him when he was appointed the Principal of the Sacred Heart Seminary in Akure. It was on a Saturday that was designated as a free day to go out of the school compound for those of us in the boarding house. After the talking and eating, he gave me one pound without asking for any money. It was when I returned to the school that, I remembered that the form for the entrance examination to University of Nigeria which I received from the post office the previous day was under my pillow. I used the one pound to buy postal order and returned the form with the money. Were it not for that money, I would not have filled or submitted the form for the entrance examination to University of Nigeria, Nsukka. I passed the entrance Examination and eventually went to the University for my BSc and PhD degrees.

In my second year in the University, Professor Ezedinma (my 9th Angel) told me on the foot path in front of the College while exchanging greetings on one morning that my performance in his course was impressive. He said further that he would recommend me for a scholarship for my Master's degree after my graduation. Inside me I said, who wants a Master's degree when I was still battling with a tough first degree. Professor Ezedinma also supervised my undergraduate research project. He rated my thesis so high and told me to write the research up for publication in a journal. He then sent the manuscript to Ghana Journal of Agriculture for publication.

The paper was accepted with minimal corrections and published in 1978.

When I came with my family for my BSc graduation ceremony at Nsukka in December 1976, Prof. Ezedinma informed me that the Postgraduate form was out and I should go and complete it. He also recommended me for the Ford Foundation Scholarship Research to pursue my postgraduate research work at IITA, Ibadan. On July 14, 1977. I got three letters; One was a letter of offer of admission to University of Nigeria, Nsukka for my MPhil/PhD degree; Two, was a letter from IITA Ibadan offering me a Ford Foundation Scholarship for my PhD Research, Three was a letter that informed me that I passed the entrance examination to the Nigerian Defense Academy and to come to Kaduna by the cheapest transportation means for a three weeks drilling and selection into the Nigerian army. I took me one week of fasting and prayer to decide to go for my postgraduate studies and abandon the attraction to the Military.

In Nigeria, the first PhD work on African traditional Cropping System was done by Dr. Fagbamiye at the University of Ibadan in 1977. That year, 1977, I came in as a second PhD researcher on African traditional Cropping Systems at the International Institute of Tropical Agriculture, IITA, Ibadan, Nigeria following a recommendation to IITA by my Dean, Professor F.O. C. Ezedinma of blessed memory for me to carry out my PhD research as an IITA's Research Fellow through grant from the Ford Foundation of America. At IITA, Dr. Fagbamiye and I had the privilege of being supervised by the same internationally renowned and tireless researcher in person of Professor Bede Okigbo (My 10th Angel), who did a lot of pioneering research in IITA along with other international scientists in the Farming Systems Programme. Professor Okigbo was like a father to me at IITA just as professor Ezedinma was to me at Nsukka. They liked my research works and write ups and talked to me as if we were academic peers, even at my tender age. They both wanted me to take up employment at IITA or Nsukka after my PhD. Professor Ezedinma even went further to advise that with the pace of my research, I could be promoted to Senior Lecturer in two years and a Professor in five years if I accepted his offer of employment in my Department at the University of Nigeria, Nsukka. I declined their offers because I wanted to spend more of my private time doing research on my discoveries rather than concentrate my time on cropping systems research alone.

Dr. Charles Sloger (my 11th angel) was the Nitrogen Fixation Advisor in Washinton DC. He came for the Conference on Nitrogen Fixation that held at IITA late in 1991. After listening to my Paper at the conference, he asked me if I could come to the Soyabean and Alfalfa Research Lab in Maryland for Nitrogen fixation research. I was overwhelmed with the urge of the Leader of the lab and Dr. Sloger for me to continue working in the Lab, but I decided to go back to FUNAAB to honour my agreement with the University that I would only spend six months in the Lab at Maryland.

I am exceedingly grateful to the Federal Government of Nigeria, the Ford Foundation of America, the Management of IITA, the USAID and the Federal Ministry of Agriculture Abuja/World Bank for the financial supports I received through their scholarships, fellowships and grants in the course of my career.

It was during my visit to Maryland that I had time to monitor the findings and projects of the National Aeronautics Space Administration (NASA) in Washington. Based on the relationship between my hyperspaces research and the puzzles that the Apollo missions discovered about the moon, I wrote in December 1992 to advise the NASA to stop the implementation of a planned 30 billion dollar Lunar Harvest Project which could alter the equilibrium between the Earth, the Moon and the Sun and cause this civilization to be buried under the sea like it happened during the time of Noah. The project never took off thereafter.

I offer great thanks to my angels for taking care of one of

their own, because God ordained that I will cross their path and they will guide and guard my footsteps to fulfill my mission here on planet earth. And to God be the Glory.
Looking back now, I wonder if my rational mind made the right decisions by rejecting some of their advice.
I wish to express my sincere appreciations to a number of great personalities who I had sought their advice on the direction of my research findings and inventions for their counsel and words of wisdom.

Rev. Bishop Michael Fagun has been a spiritual Father to my entire family and myself right from my secondary school days to my postgraduate training days at IITA. He helped to proof read and to review my first book on science and religion and offered very useful suggestions on the way forward on my discoveries and invention. Thank you, my lord.

Three years after I joined Obafemi Awolowo University (then University of Ife) as a Lecturer, I went to Chief Obafemi Awolowo on one on one at Ikenne in 1983 during which I requested him to support the establishment of a Centre for Advanced Studies in Nigeria, where scientists who have notable inventions like me, could perfect their inventions for commercialization since Nigerian Universities are not designed to harness high level discoveries and inventions such as mine. Papa Awolowo asked me to show him some of my discoveries and inventions. After I did, he asked if I am a member of any mystery school and I said, no. He immediately understood the import of my work. He said I was too young for the kind of discoveries I made and my ideas were too advanced for my age. He suggested that I should enroll in a mystery school for me to understand the importance of my discoveries. He said I should come back after enrolling and that would be when he could assist me. I did not go back to Papa Awolowo because I did not see any reason why I should join a mystery school before he could assist me on my discoveries and inventions. It was not until 1992 when I was in the US as a visiting scientist that I bought a book on the teachings of the Ancient Mystery Schools. In that book, I found out that my mathematical models for evaluating the performance of simple to complex crop mixtures and my paper models of close packing systems had been used for the formulation of the teachings and rituals of the Mystery schools for thousands of years. The only difficulty I had with the mystical tradition was that I could not see any relationship between my mathematical description of evolution complexity and their ceremonial practices.

I wish to thank Mrs. Selina Macaulay, founder of the Esoteric Library in Abeokuta who connected me to Justice Adewale Thompson in 1996. Justice Adewale Thompson, of blessed memory, did a page on my research discoveries in the Tribune Newspapers in 1996 under his regular column, “Megaforce” and chronicled my research in his encyclopedia of "Black Peoples of the World".

I sincerely appreciate Prof. T. O. Tayo, the pioneer Dean of the College of Plant Science and Crop Production and later the Deputy Vice Chancellor of FUNAAB for his personal interest in my research as the Chairman of the Advisory Committee on my Futuristic Research Project in years 2004 and 2005.

I sincerely thank the Pioneer Vice-Chancellor of FUNAAB, Professor N. O. Adedipe, the subsequent Vice-Chancellors; Prof. J. A. Okojie, Prof. I. F. Adu, Prof. O. O. Balogun and the present Vice-Chanllor, Prof. O. B. Oyewole for giving me the time, space and freedom to carry out my research and write my journal and book publications.

I hereby acknowledge those who have taken time to acknowledge my work;
President Bill Clinton of USA while in the White House in 1996,

Director of Center for Frontier Studies at Temple University USA

I acknowledge the appreciation of the Director, Solar System

Exploration Division of the National Aeronautics and Space Administration (NASA) Washington, in USA for my interest in their space research programmes.

I appreciate the various International Biographical Centers in USA and Europe that dotted my name on their Bibliographic Citations of notable achievers in science and engineering.
I sincerely thank the Head of my Department, Dr. Adeyemi and my colleagues in the Department of Plant Physiology, Prof. Lagoke, Prof. Olowe, Prof. Elemo, Dr. Atayese, Dr. Oyekanmi and others for their cooperation and for the good working relations I have enjoyed with them.

I appreciate the Dean COLPLANT, Prof. Goke Bodunde and other Senior Colleagues in the College; Prof. S. O. Afolami (Now Vice Chancellor of the Augustine University in Lagos State) Prof. M.O. Adetunji, Prof. Ariyo, Prof. Olasantan, Prof. Ajala, Prof. David Ojo, Prof. Kehinde, Prof. Enikuomehin and others too numerous to mention for the good working relations we have enjoyed together.

I sincerely appreciate the Director in the Vice-Chancellors Office, Mrs. Kuforji and my colleagues who kept asking; "when are you going to give your inaugural lecture?"

I express my sincere appreciations to the Chairman of the

University Publication Committee Prof. Oguntuase and his members for editorial assistance on this manuscripts.

I wish to recognize my undergraduate students in the Faculty of Agriculture, Obafemi Awolowo University who are now in FUNAAB

Dr. Ashaolu of COLAMRUD, Dr. Osipitan in COLPLANT, Prof. N. O. Ikeobi of COLANIM

I wish to recognize my postgraduate students in the Faculty of Agriculture, Obafemi Awolowo University; Prof. Kehinde Okeleye, Vice Chancellor Crescent University and Prof. V. O. Olowe, in IFSERA/COLPLANT, FUNAAB

I wish to recognize my undergraduate students in the College of Plant Science and Crop production who are now my academic colleagues in FUNNAB; Dr. Atungu, Dr. Adebisi and others.

I wish to recognize the MSc. and PhD students that I have supervised here in recent times; Dr. Wale Salau, Dr. Soretire, Dr. Thomas Fabunmi of FUNAAB and Dr. (Mrs) Saheed of Lagos State Polytechnic.

I thank God for the good children he gave me. I thank God that they can now forge ahead with their lives without worrying too much about their day to day lives. I know that my God will always be there for them at all times. I thank you for your love and support.

To my wife, Monisola, I thank you for being there to take care of the family and for keeping the peace during my solitary mental sojourns into the world of the abstract while writing my research papers and books.

Christiana Olubunmi has always been there to take care of my tourism and research project at the Foundation for Advancement of Culture and Science back home Foundation and research projects, back home. I thank you very much for your support.

I sincerely thank our Rev. Father Charles Odeyemi, our Priest at St. Theresas' Catholic Parish, Ise-Ekiti for his constant prayers.

Thank you all and God bless. I wish you all journey mercies to your various destinations. Arina kore, afoya ibi.

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MY BACKGROUND

I was born in Ise-Ekiti, Ekiti State to the family of Pa and Mrs. Gabriel Akingbade Adetiloye. My Father was the first Baba Egbe of St. Theresas Catholic Church in Ise-Ekiti. My mother came from the Adelabu ruling house of the Oba Ewi of Ado Ekiti.

My Father was possibly regarded as the most successful farmer in Ise-Ekiti because he cultivated close to fifty hectares annually. The farm land was planted to cocoa, kola, oil palm, para rubber, cassava, plantain, cocoyam, yam, maize in diverse forms of mixed intercropping. Our farm houses were usually filled with thirty to forty annual contract farm workers from the Eastern and Northern parts of Nigeria. Indigenes of Ise community gladly came to work for my father on our farm because foods of all types were super abundant on the farm. Farm labours got their pay as at when due. Hence members of the community who needed money for social functions or to pay their children school fees would come to work on our farm because they were sure of their pay. However work normally started at 6 am and closed at 6pm with my Father. The hard work that accompanies each pay, would make anyone who is asked to contribute outrageously for social functions or dresses to reply sharply that; "Do you want to send me to Adeti Farm?" (Se wa ran mi lo s'oko Adeti?). This is now a common adage in my town for people to cut their coat according to the size of their cloth.

I learnt all the hard work and practical aspects of farming with my father on the farm. I only learnt the science of Agriculture in the University. Most of the migrant workers now farm for themselves and even as a professor of Agriculture, it would be impossible to achieve the level of success that my father achieved in farming without modern farm machineries.
My father being, the President of the Catholic Church in Ise-Ekiti, exposed his children to a strong Catholic tradition at home and in School hence my siblings and I went to Catholic schools for our primary and secondary education.

I started my Primary School Education at St. Theresa's Primary School in 1959. I complete my Primary School Education in 1964. I started my secondary school in 1965 at Ise-Emure Grammar School In 1968, I transferred to Notre Dame Grammar School where I completed my secondary school education in 1970. I taught under the Schools Board in

Ansar-Ud-Deen Primary School in 1971. I went to Oyemekun Grammar School Akure, in Ondo State for my Higher School in January 1972 I secured admission to the University of Nigeria Nsukka the same year for my first degree in Plant/Soil Science. I was offered the Federal Government of Nigeria scholarship in 1973 for the remaining three years of my four-year degree programme.

I graduated in 1976. My National Youths Service was undertaken at the Ministry of Agriculture in Onitsha, Anambra State from August 1976 to July 1977. I was offered Postgraduate Admission to the Department of Crop Science of University of Nigeria, Nsukka in July 1977. Professor F. O. C. Ezedinma, my undergraduate project supervisor also recommended me for a Ford Foundation Research Fellowship, which I secured in July 1977 for my postgraduate research work at the International Institute of Tropical Agriculture {IITA) Ibadan. I started my MPhil/PhD at the University of Nigeria Nsukka in September 1977, got a conversion to straight PhD in 1978 and completed my PhD research at IITA in February 1980 and the PhD thesis in August 1980 and the degree was awarded in December 1980.

I secured a University teaching and research appointment in 1981 as a Lecturer II in the Faculty of Agriculture, of Obafemi Awolowo University, Ile Ife, Nigeria. I went back to

IITA, Ibadan from April 1989 to March 1990. Thereafter, I joined the Federal University of Agriculture Abeokuta in 1990.

I was the Head of Department of Crop Production and Crop Protection from 1990 to 1994 and the pioneer Head of Department of Plant Physiology and Crop Ecology (now the Department of Plant Physiology and Crop Production) from 1995 to 2001.

While in this University;

- I went on study as a visiting scientist sponsored by the US Agency for International Department (USAID) from September 1992 to March 1993 to the Soyabean and Alfalfa Research Lab of the US Department of Agriculture in Maryland, USA.
- I spent my first sabbatical leave while in FUNAAB at Igbenedion University, Okada, in Edo state in year 2002/2003.
- I spent my second sabbatical leave in 2010/2011 in the Faculty of Agriculture, Department of Crop Science at Obafemi Awolowo University where I started my University teaching and research career in 1981.
- At FUNNAB, I secured N7500 research grant in 1990 for plantain research.

A second research grant of N100,000 naira was received in 2006 to carry out a collaborative research on the effect of my regular space enclosures on pathogenic microorganisms when the present Vice-Chancellor was the Director of the University Research and Development Centre, RESDEC. The Vice-Chancellor is unrelenting in his support for possible source of grant to support my seed energizing technology invention, and for which I greatly appreciate you, Sir.

I secured $75,000 grant from the World Bank assisted national Agricultural research project in 1996 for my inoculant nitrogen fixation and inoculant research.

I was appointed a Senior lecturer in 1990 at FUNAAB. As a Head of Department in a new University for eleven straight years and with the scarcity of research facilities for quality research, I was able to publish to my standard and got promoted as an Associate Professor in 2003 and finally a Full Professor in 2005, twenty five years after my PhD. And to God be the Glory.