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HORTICULTURE: THE UNDER EXPLOITED GOLDMINE IN AFRICA

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The Vice-Chancellor, Deputy Vice-Chancellors (Academic & Development), The Registrar and Other Principal Officers, The Dean of the College of Plant Science and Crop Production, The Dean of the Postgraduate School, Deans of Other Colleges, Directors of Centres, Heads of Departments, Distinguished Professors, Fellow Lecturers, Guests, Ladies and Gentlemen, and Great UNAABITES.

1.0. INTRODUCTION

I would like to express my gratitude to God Almighty, and also grateful to my Dean, on behalf of the College, for the honour of being nominated to present the 6th inaugural lecture from the College which is the 3rd coming from the Department of Horticulture today. I deeply appreciate this honour because it is such a personal pleasure to share my experience over the years in the academics with my colleagues and the public. I feel bound by a sense of respect and admiration for this academic profession and the educational system in totality as these have always held a special place in my heart and that of my late father.

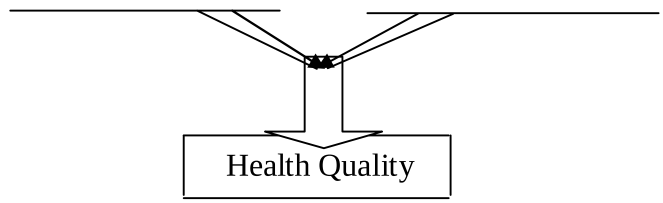
At the beginning of my career in 1982, I had many options: my dilemma and final choice of research interest can be expressed by a general saying as ably stated by Robert Frost:

"I shall be telling this with a sigh. Two narrow paths diverged in a forest.
And I….I took the one-less travelled by. And that has made all the difference"

The narrow path with limited traffic in African Agriculture is **"Horticulture"**. What we are celebrating today is the outcome of that brave decision. By willingly taking a path less travelled by, I found in the complexity of tropical agriculture a new challenge and stimulus for my scientific instinct and curiosity, and together with my collaborators have devoted my over twenty-eight-year experience to a systematic exploration of the **sustainability**, **food sufficiency** and **health aspects** of horticulture. My duty, as a Farming Systems Horticulturist, is to throw some light on horticulture; the oldest branch of agriculture but youngest in research in Africa.

Among the rungs of life basic needs is food - material that provides nutrients needed for energy, growth and nourishment. Perhaps, next to it is the need to live in a beautiful environment. **Food sufficiency** and **Environmental quality** are the two big issues in recent time for **Health quality** in Africa that received much global attention. The two are related essentialities that permit a good quality in a human health stream and could be regarded as the **'Siamese' Y-shaped** attributes of horticulture (Fig. 1a).

(a)



(b)

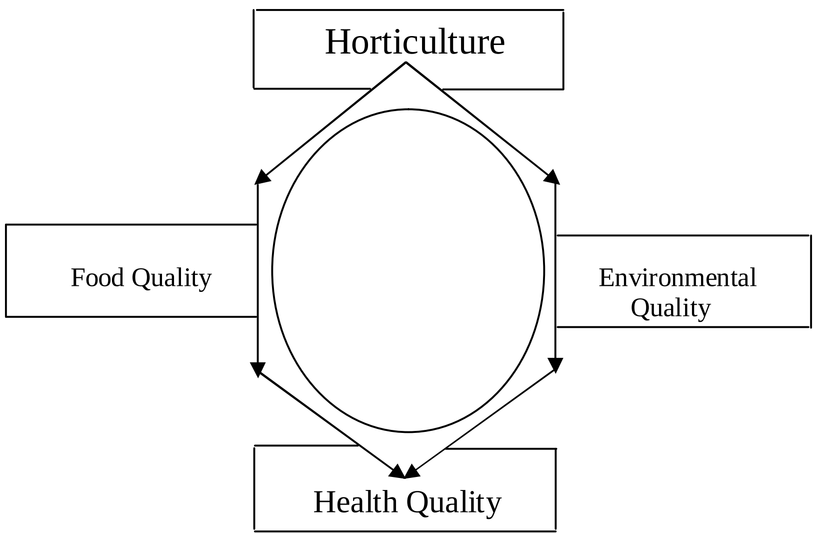


Fig. 1: (a) 'Siamese' Y-shaped and (b) Benzene-ring shaped attributes of horticulture

The issue of **Food sufficiency**, **Environment quality** and **Health quality** lies at the heart of horticulture. The three attributes and horticulture itself give a shape that looks like a benzene compound molecular structure (Fig. 1b). In benzene structure, in which six carbon atoms are bonded in a hexagon by alternating single and double bonds, it is difficult for external electrons to easily enter. So, it is difficult for a deadly disease to easily attack people that adopt **benzene-ring shaped** attributes of horticulture.

Provision of good food and healthy environment is a critical step towards sound health quality. Experts recognize access to good environment as a priority for human health's improvement. In the UK, the expression of good sanitation in the 1880s contributed to a 15-year increase in life expectancy. A good environment is a key to a good health. But recent projections suggest that the Millennium Development Goals for sanitation target will not be met until 2108 in Africa. We may think that the year 2108 is a great distance away; the projection was based on concrete facts of the present sanitation situation and the magnitude of health improvement of the entire populations that is needed to be provided in Africa. We need to heed this timely warning.

1.1. The Ordinance and Scope of Horticulture

Horticulture is an occupation ordained by God; it has continually sustained mankind as a source of food, purification and aesthetic gratification of the environment. God planted the **Garden of Eden** and then put Adam in the Garden to work it and take care of it for his existence, recreation and sustenance (Genesis 2: 8, 15).

"And God made the land to produce all kinds of fruit-bearing plants,
And there came Citrus, Plantain, Banana, Cashew, Mango, Coconut, Grapes,
Apple, Papaya, Oil palm, Guava, etc. and all kinds of Vegetables,
That were pleasing to the eye, and good for food; And God saw that it was good".

1.1.1. The term Horticulture - has been given various definitions. According to Janick (1986), horticulture is a branch of agriculture concerned with intensively cultured plants directly used by people for food, medicinal purposes or aesthetic gratification. Edmond *et al*. (1983) defined horticulture as the science and technology involved in the production, processing and merchandising of fruits, vegetables, flowers and ornamentals. The aesthetic use of plants is a unique feature of horticulture, distinguishing it from other aspects of agriculture. It is this uniqueness which has led to its universal popularity. Horticulture involves intensive cultivation (***cultura***) of high value crop plants within a protected area garden (***Hortus***). Bacon (1960) described **Garden** as the purest of human pleasures. According to Gurney (1960), one is nearer to God's heart in a garden than anywhere else on earth. Horticulture indeed represents the aristocracy of crop husbandry (Turkey 1965).

1.1.2. Scope of Horticulture - has been equated with floriculture by people who are ignorant of the discipline. Horticulture is an **art** requiring unique skills of ancient practices; a **science** involving theory and practice of cultivating fruits, vegetables and ornamentals, and designing aesthetic landscapes; a **vocation/business** involving an outlet for revenue generation, recreation and relaxation. Horticulture has four general sub-categories:

● **Pomology -** the practice of cultivating fruits such as citrus, cashew, plantain, cocoa, coffee, oil palm, etc. for food, beverages, oil-seeds, etc.

● **Olericulture** - the practice of cultivating vegetables and spices for food, composite seasonings and medicine.

● **Floriculture -** the practice of growing ornamentals, cut flowers, pot plants, shade trees and ground covers for environmental beautification, protection and purification (e.g. potpourri), and medicine and honey making.

● **Landscape Gardening -** the practice of enhancing the appearance of land, buildings, gardens, grounds and recreational areas by altering its contours and planting shade trees and ornamentals for aesthetic environment.

Mr. Vice-Chancellor, Sir, our professional experience has shown that horticulture is a big source of treasure in Africa. However, the present situation of development in horticulture when compared with the huge outlays and efforts invested on it and its contributions to national development in Africa can be aptly summed up as **'HORTICULTURE: THE UNDER EXPLOITED GOLDMINE IN AFRICA'**.

Before I proceed, it seems pertinent and instructive to recollect the advent of agricultural production systems concept, horticulture development in Africa, and Africa's position in the World Horticulture. From there we shall see where, why and how the horticulturists come in.

2.0. AGRICULTURAL PRODUCTION SYSTEMS

2.1. The Systems Concept

According to Okigbo (1982), the general Systems Theory was advanced by Bertaleffy in 1950. Since then, several scientists have elaborated it; we now have a special problem solving approach called **Systems Analysis**. According to Spedding (1975), a system, as a whole, has parts that have internal and external controls and a purpose to be achieved. The source of transforming a system lies within itself. Agriculture is an open system in which there is a continual input and output of both energy and materials. According to Einstein's **Theory of Relativity**, mass and energy are equivalent and inter-convertible. So, no system can be absolutely closed. African agriculture as a system is no exceptional.

2.2. Production Systems

An agricultural production system consists of one or more enterprises in which sets of resources and inputs are uniquely managed by the farmer in the production of one or more commodities to satisfy human needs for food, fibre, various products and monetary income (Okigbo 1982). In Africa, horticulture and agriculture are difficult to separate; fruit and vegetable crops have always been an integral component of mixed systems. There is rarely a subsistence farm where these essential crops do not feature prominently in an assortment of mixtures with food and/or economic tree crops. This makes tropical farming systems the most complex agricultural system of all (Norman *et al.* (1976). The complexity reflects diversity of socio-economic interest of the people, climate and soil (Spedding (1975), which must be taken into consideration before any meaningful agricultural development can be effected.

It is evident that fruits and vegetables have played a central role in human existence. The prehistoric man relied mainly on gathering for his everyday quest for food. Gathering as a system requires a large area per person, and it is space-wasting, time-consuming and unpredictable. The Neolithic period, the latest period of the Stone Age, between 8,000 and 5,000 BC, was characterized by the development of settled agriculture. A wide-spread food revolution was in place with rudiments of agricultural production. Crops began to be cultivated; leading to gradual shift from gathering to domestication. Gathering provides important additions to the food gained from subsistence farming. In Africa, natural trove for horticultural crops: oil-palms, African bush mango, star apples, locust bean, papaya, waterleaf, etc. still provide food for human existence.

As human population increased crop cultivation and the act of refining and preserving food to augment natural supplies became important for the entire food-cycle chain. In Africa, two basic types of production systems have changed little during the 20th century. **Savanna Agriculture -** where cereals (millet, sorghum, rice, maize); food legumes (cowpea, peas, soybean, groundnut), and vegetable crops are widely grown. **Rainforest Agriculture -** tree crops (cocoa, kola, coffee, oil palm, plantain); starchy tuber crops (yams, cassava, cocoyam), and vegetable crops are mostly cultivated.

Table 1: List of plantation crops in relation to kinds of intercrop association in tropical agriculture

Common Name	Scientific Name	Cash crop	Cover crop	Pasture /forage crop	Shade crop	Wind break/ shelter	Comp-anion crop	Live support
Tea	*Camellia sinensis*				*			
Oranges	*Citrus* spp.	*					*	
Coconut	*Cocos nucifera*	*	*	*		*	*	
Coffee	*Coffea* spp.	*			*			*
Kola	*Cola* spp.		*		*			*
Oil palm	*Elaeis guinensis*	*	*	*				
Mango	*Mangifera indica*	*	*					
Cocoa	*Thoebroma cacao*	*					*	*

Source: Okigbo (1980)

2.3. Diversification of Tropical Agriculture

Many scientists have described diversity of tropical farming. According to Okigbo (1980), tropical agriculture is associated with different cropping systems and occurrence of crops in the systems (Table 1). There are two categories: **Traditional farming systems** and **Modern farming systems**. Professor T.A.T. Wahua in his 2002 inaugural lecture, 'Traditional Farming Systems: Bedrock of National Development in Africa', discussed extensively the **Traditional farming systems**. In this lecture, we shall discuss the **Modern farming systems horticulture-** Plantations and Market Gardening.

In tropical agriculture, horticultural crops serve many purposes which mathematical models do not express. Sometimes, they provide windbreakers, live supports, shade plants and shelterbelts that protect the soil, safeguard the environment and lessen the risk of desertification. The soil which being cultivated year-round is never left uncovered. The plant roots fix the soil on sloping ground, thereby reducing erosion and nutrient loss. There had been no mathematical models yet developed which completely expressed the diversity, resource use, pest control, and tackling of climate change which tropical farming is well known for. Tropical agriculture involves several important processes that do not fit directly into the mathematical models currently used.

2.4. Farming Systems Determinants

Norman *et al.* (1976) described tropical farming systems in which a set of related and dynamically interacting elements is manipulated by the farmer to achieve a specified production objective. The **Total Environment** in which the farmer operates is divided into two elements: the **Technical** and the **Human**. The **Technical Elements** involve physical factors like the climatic, edaphic, biological, chemical and mechanical aspects of the environment. This is where pure and applied scientists contribute to agriculture. The **Human Elements** comprise the **Endogenous** - factors that are largely under the control of the farmer like decision making, labour and management technology, and the **Exogenous** - factors largely outside the control of the farmer like the government policies on infrastructure, quantities as well as absolute and relative prices of inputs and outputs, institutional elements and community socio-cultural set-up. Similarly, the agricultural economists and extension specialists come in here.

Management of the vagaries of the weather is the most challenging task for African farmers. The human elements have not been helpful either. The environment is extremely difficult to manipulate, characterized by highly weathered and infertile soils, and unpredictable rainfall. Also, the temperature and light intensity are generally high, permitting pest development and weed growth throughout the year (Olasantan 1999a).

3.0. HORTICULTURE DEVELOPMENT IN AFRICA

3.1. Introduction of Horticultural Crop Plants

Most horticultural crop plants were introduced into Africa in the 19th and 20th centuries mainly by the Portuguese and other European traders, colonial authorities and individuals. Cocoa was first introduced to Nigeria by Chief Squiss Ibaningo from Fernando Po to Bonny in 1874, to Ghana by Chief Tetteh Quarshie from Fernando Po to Akwapim in 1879, and to Bingerville near

Abidjan, Cote d'Ivoire in 1895. Establishment of the Bonny Botanic Gardens in 1874 in Nigeria and the Aburi Botanic Gardens in 1890 in Ghana undoubtedly resulted in introduction of numerous horticultural plants to West Africa.

Since then numerous horticultural species and varieties have been introduced into the continent by various institutions; Horticulture Division of the Ministry of Agriculture, Horticultural Research Institutes, Oil Palm and Cocoa Research Institutes, horticulturists, etc.

3.2. Cultivation and Diversity of Horticultural Crop Plants

Depending on agro-climatic situations tree, fruit and vegetable crops are grown in mixed systems mainly by traditional farmers. Tree crop plantations, including cocoa, kola, oil palm, coffee, and tea are grown on a much large-scale for both domestic and export markets. Flower and ornamental gardens are cultivated mainly by urban and peri-urban growers. Market gardening with exotic vegetable varieties later commenced also in urban areas mainly for the Europeans and a few African elites. Cultivation of fruit and vegetable crops and ornamentals has increased tremendously in recent time in African big cities due to urbanization, modernization, and direct benefits from the proximity of the urban markets.

3.3. Establishment of Horticultural Research Institute

Between 1861 and 1950, agriculture development in Africa meant serving the colonial masters by establishing plantations and export-markets for horticultural crops produced mainly by rural farmers. Ibadan Moor Plantation, the first Nigeria's major research station was also established in 1899 by the British Cotton Growers Association. This was 70 years after the founding of Rothamsted Experimental Station in Great Britain and 23 years after the founding of the Connecticut Agricultural Station, the first experimental station in the USA (Lucas, 2007). In 1924, the second Nigeria's major Agricultural Research Station was established at Samaru.

Despite the considerable importance of horticulture little efforts were made on research to exploit its full potentials until the 50s-70s. For example, Nigerian Federal Government reorganized agriculture, created provisions for commercial crops research, and established farm settlements, research institutes, and tree crop plantations in 1950–1968. The decade between 1968 and 1978 saw another type of inner awakening that encouraged production of food, fruit and vegetable crops to support the teeming population in the country. The Federal Government Agricultural Research Institutes Establishment Decree of the late 70s led to the establishment of 18 National Agricultural Research Institutes (NARIs); three of them had mandates for specific horticulture commodities. This marked the beginning of organized research work in horticulture in tropical Africa.

The past decades have seen remarkable progress in the growth of Agricultural Research Institutes in Nigeria. Indeed, Nigeria, the black giant of Africa, then had the best agricultural research network in the continent. According to Dr. I. Stifel former Director of IITA, Nigerian scientists in the Research Institutes represent 45% of the African agricultural scientists in West and Central Africa. The three Horticultural Research Institutes are:

i/ Nigerian Institute of Oil Palm Research (NIFOR) in Benin - Established in 1938 as West Africa Oil Palm Research Institute (WAIFOR); its national mandate was to carry out research into genetic improvement, production, processing and utilization of oil palm, coconut, date palm, raphia and ornamental palms.

ii/ Cocoa Research Institute of Nigeria (CRIN) in Ibadan - Established in 1964 as fallout of West Africa Cocoa Research Institute (WACRI) established in 1944 in Ghana and the national mandate was to carry out research into genetic improvement, production, and utilization of cocoa, cashew, kola, coffee and tea.

iii/ National Horticultural Research Institute (NIHORT) in Ibadan - Established in 1975 as United Nations Development Programme/Food and Agriculture Organization (UNDP/FAO). Its mandate was to carry out research into genetic improvement, production, processing and utilization of tropical fruits (citrus, mango, plantain, pineapple, papaya, guava, etc.), vegetables (tomatoes, onion, pepper, amaranths, melon, okra, fluted pumpkin, *Solanium* spp., etc.), and ornamental plants.

The research institutes are also responsible for provision of support services for the transfer of technology and update farmers’ skill and knowledge on their mandate crops, through farm level training, information dissemination, and collaborative research activities with National and International agencies, NGOs, and Universities.

As part of the grandiose efforts towards agricultural/horticultural development the Federal government orchestrated schemes and programmes with overlapping functions such as:

1. The National Accelerated Food Production Programme – NAFPP (1973)
2. The Agricultural Development Programmes– ADPs (1973)
3. National Seed Service (1976)
4. Operation Feed the Nation – OFN (1976-1979)
5. River Basin Development Authorities (1977)

6. Green Revolution (1980-1983)
7. Directorate for Food, Roads and Rural Infrastructure – DFRRI (1986)
8. The National Agricultural Land Development Agency – NDLDA (1991)

3.4. Horticultural Education and Associations

Horticultural education continues to grow in most African nations after attainment of independence. Agriculture is offered as a science subject with aspects of horticulture at secondary and tertiary educational levels. For example, undergraduate students in our Department specialized in Horticulture since 1990 in the B. Agric. programme. In most African universities, horticultural courses have been consolidated up to post-graduate level.

Recently, our Department developed new courses on B. Horticulture degree with the intention to making horticulture professional. Mr. Vice-Chancellor, Sir, this is still our quest. The courses covered various aspects of floriculture, landscaping, organic fruit and vegetable production, and environmental horticulture. These courses are also relevant to urban developers, landscapers, and students specializing in human/urban geography, and home or urban management. This aspect of horticulture is very important in our curriculum in view of the unprecedented increase, in recent time, in the rate of modernization, demands for organic foods, aesthetic urbanization, and cityscapes in Africa.

Several associations which are mainly commodity or societal based have been formed such as co-operative societies for cocoa, oil palm, coffee, cashew, etc., and associations for tomato, pineapple, mango, citrus or flower growers to offer bulk supplies to buyers and provide export potentials. Universities and Research Institutes also form their associations like Horticultural Society or Institute of Horticulturists.

3.5. General Constraints

Despite the huge outlays and efforts made by governments and individuals, horticulture development in Africa has not really yielded the desired goal.

i/ Farmers' perspectives and priorities were not properly considered in the planning and execution of research institutes which were established to transform rural areas and increase production of food and horticultural crops.

ii/ No Departments of Horticulture, until very recently, in most African universities to collaborate with research institutes and enhance man-power development. Presently, very few professional horticulturists that exist in Africa find themselves in other areas of agriculture and vice versa as a result of ignorance of the discipline of horticulture in official circles.

iii/ Funds for agricultural and rural development have always been a major constraint. Those provided for fruit, vegetable and ornamental research programmes by ministries of agriculture, donors, banks, etc. are yet to enhance adequate support services and skills in horticultural industry. For the past 25 years, agriculture has been under-funded in Africa despite the Maputo declaration, where African Heads of State agreed to invest 10% of GDP.

4.0. WORLD HORTICULTURE: THE POSITION OF AFRICA

Mr. Vice-Chancellor, Sir, we shall briefly examine the impacts of horticulture, giving its full priorities, in some nations of the world in the last ten years or so. This will enable us to appreciate the position horticulture occupies in the development of such nations.

4.1. Production Volume: Fresh Fruits and Vegetables

The FAO estimates of the yearly fresh fruit (1.6%) and vegetable (3.2%) production show an increase that matches the growing demand. Over the last 10-15 years, vegetable production increased by 56%. Overall, the largest increase in production for both commodities has always been in Asia (China) and in South America (Brazil and Chile).

Table 2: Production volume (1000 MT) and growth rate of some fruits and tomatoes

	Production average					Growth rate (%)				
Country	Citrus	Grape	Banana/ Plantain	Apple	Tomato	Citrus	Grape	Banana/ Plantain	Apple	Tomato
Developing										
Africa	**7423**	**1290**	**6581**	**851**	**8732**	**1.8**	**0.14**	**1.77**	**16.0**	**2.53**
Latin America	30780	5414	22870	3213	584	3.7	5.41	3.49	3.52	2.47
Asia	22137	9802	23119	18815	29547	7.3	2.96	3.39	6.69	6.69
Oceanic	–	–	687	–	–	–	–	3.03	–	–
Developed										
European Union	9161	23506	–	9563	12792	1.3	– 2.97	–	– 0.62	1.43
North America (USA + Canada)	13828	5476	–	5498	12021	3.6	0.96	–	2.42	4.46

Source: World Conference on Horticultural Research -WCHR (1998), updated (2010)

The leading vegetable producer is Asia with 61% of the world output and a yearly growth of 5.1%. The EU comes next with 11% (Table 2). Chile has become a major world producer of fresh orange fruits with a yearly increase of 3.4% (45% of its production volume). The Chinese production of oranges rises by 14.9%/year and is now as important as the total orange production of the EU. Encouraged by good producer prices, orange and mango were planted in Brazil and

Peru between 1988 and 1995. Globally, about 30 million tonnes of mango are produced yearly with an average rate of 2.6%, Asia, South America and Africa account for 77, 13 and 10%, respectively. The EU has for a long time the largest world producer of apples, with 20% of the world volume. China now has 23% of the world production of apples, larger than any other country, with a yearly increase of 16.2%. Africa is the least producer of citrus, grapes and apples.

Banana and plantain rank second and fifth, respectively, among the world's major fruits. The production has an average of 3%/year. Africa is the third largest producer of plantain and banana after Asia and Latin America.

Over 80 million tonnes of tomatoes, 19% of the fresh vegetable production in the world, are produced yearly. The world production of tomatoes rises by 2.9%/year and the EU is the largest single producer with 13 million tonnes or 18% of the world output, but a yearly growth of 2%. Only Turkey has 7.6% of the world output and it is rising by 4.9% yearly. The USA and Canada are the next important producers with 12 million tonnes. Tomatoes are the USA third important products after citrus and grapes. Africa and Latin America are the first and second lowest producers of tomatoes, respectively.

4.2. Trade – Export and Import Volumes: Fruits and Vegetables

Averagely, about 9.7% of world citrus production is exported fresh, a volume of 8.9 million tonnes (Tables 3 & 4). Oranges account for 50% of citrus exports. Approximately 20% of the world table grape production is exported. Chile alone accounted for almost half of the world exported growth. South Africa increased exports substantially (with 60% of which was to EU) as the third largest exporters of citrus after the USA and Spain. The EU accounts for approximately 50% of world imports. In 2007, only 850,000 tonnes of total mango fruits (2.6% of world output) were exported. Brazil, Peru, Mexico and India are the world leading exporters of mango to the EU and US markets. Brazil and Peru lead with 70% of global trade.

World banana/plantain trade has become more concentrated, it accounts for about one third of the world's total fruit exports (over 13 million tonnes, almost 25% of production). The largest exporting nations have shown the largest growth during the past 15 years. Latin America accounts for nearly 75% of global exports while ACP nations account for only 17%. The EU is the world's biggest importer of bananas (almost 50% of the market), followed by the USA. Globally, import volume of banana/plantain increased by more than 3.5 million tonnes.

Only four percent (4%) of the world production of tomatoes is exported fresh. The Netherlands is the leading exporting nation of the world. Spain is the number two, providing

45% of the northern EU market, and Mexico is the number three, supplying 98% of the import of the USA. Germany is the number one importing country of tomatoes in the world, and about 55% of her import comes from the Netherlands. The number two importing country is the USA. Generally, Africa has the lowest export and import volumes for tomatoes.

Table 3: Trade (Export Volumes, 1000 MT) of some fruits and tomatoes

	Export average					Growth rate (%)				
Country	Citrus	Grape	Banana/ Plantain	Apple	Tomato	Citrus	Grape	Banana/ Plantain	Apple	Tomato
Developing										
Africa	**614**	**2**	**346**	**0.3**	**182**	**– 3.24**	**36.8**	**9.22**	**35.08**	**6.63**
Latin America	862	520	9079	585	580	–1.12	6.89	5.98	1.76	0.95
Asia	967	118	1369	459	370	3.69	2.75	4.48	9.92	2.52
Developed										
European Union	4350	920	1043	1992	1769	4.15	3.72	11.85	4.71	7.12
North America (USA + Canada)	1201	258	387	707	173	3.89	9.41	7.29	12.81	13.32

Source: WCHR (1998), updated (2010)

Table 4: Trade (Import Volumes, 1000 MT) of some fruits and tomatoes

	Import average					Growth rate (%)				
Country	Citrus	Grape	Banana/ Plantain	Apple	Tomato	Citrus	Grape	Banana/ Plantain	Apple	Tomato
Developing										
Africa	**50**	**3**	**11**	**51**	**11**	**13.7**	**13.6**	**23.9**	**14.2**	**15.7**
Latin America	519	76	477	389	56	13.0	–	11.9	13.6	9.70
Asia	865	188	885	779	402	6.09	5.82	15.9	8.67	0.57
Developed										
European Union	4523	927	4599	2359	1595	0.29	2.45	8.86	1.43	4.03
North America (USA + Canada)	579	480	4013	229	630	3.58	3.49	3.27	–1.17	1.98

Source: WCHR (1998), updated (2010)

4.3. Consumption Volume: Fruits and Vegetables

The average world consumption of fruits is 79.4 kg/person/year and vegetables is 84.9 kg/ person/year with three groups of nations (Table 5): **i/ High consumption nations -** (> 200 kg/person/year), the rich world nations - EU, USA, Asia (China, Korea, Singapore).

ii/ Average consumption nations - (100-200 kg/person/year), the nations are USSR and Eastern European countries.

iii/ Low consumption nations - (< 100 kg/person/year**)** the poor nations with low purchasing power, situated in Africa and part of Asia. Rwanda and DR Congo are the highest consumers of fruits and vegetables in Africa. Generally, Africa has the least consumption volume for vegetables and second least for fruits, Mauritania and Somalia with the lowest records.

Table 5: Population, growth rate and consumption of fruits and vegetables

Country	Population x 1 000 000	Growth rate (%)	Vegetable (kg/person/year)	Fruit (kg/person/year)
Developing				
Africa	**660**	**2.78**	**40.1**	**69.1**
Latin America	469	1.79	42.7	74.3
Asia	3188	1.74	92.5	204.4
Oceanic	7	2.15	69.3	154.7
Developed				
European Union	370	0.37	130.7	171.1
North America (USA + Canada)	294	1.03	118.3	125.7

Source: WCHR (1998), updated (2010)

5.0. CONTRIBUTIONS OF HORTICULTURE TO NATIONAL DEVELOPMENT IN AFRICA

Mr. Vice-Chancellor, Sir, for the purpose of this inaugural lecture, we can distinguish five main contributions of horticulture to national development in Africa:

- **Food/Nutrition**
- **Trade/Economic values**
- **Medicine/Health quality**
- **Ecological attributes**
- **Domestic/Industrial disposition**

5.1. Food and Nutrition

Fruits, vegetables and spices are the most important nourishing foods, containing certain amounts of all ‘life-giving’ chemical substances that the body needs. The rise in the living standard and improvement in health quality of people have resulted in a greater appreciation of the value of these essential plants. Nutritionally, they can be grouped into:

- **Energy-giving/body-building foods**
- **Protective/curative foods**
- **Mineral nutrient-giving foods**

Africa is endowed with a variety of indigenous horticultural crops that have varied culinary heritage, curative and protective substances with rational proportions of proteins, vitamins, minerals, essential oils, aromatics, and thickening substances. Leafy vegetables have more protein contents, vitamins A and C, and calcium than those of European origin. Intake of 100-250g/dry weight would cover daily requirements for iron, and might be superior to milk as a gross source of calcium (Schmit 1971; Taylor *et al*. 1983; Oke 1985). For example, pumpkin, *Talinum*, *Corchorus*, Indian spinach, pepper and *Solanium* contain generous amounts of iron (20-374 mg/100g), vitamin A (800-6250µg/100g) and vitamin C (150-180 mg/100g). A medium-sized mango fruit provides about 15,000 IU of vitamin A. Diet essential proteins and amino acids contained in dried leaves of *Amaranthus* and *Moringa*, and mature seeds of locust beans, roselle, okra and cucurbits compare favourably with those of poultry meat, eggs and soybean (Schippers 2000; Olasantan 2001a)).

Fruits and vegetables are **Natural Biofortified-Foods** in the fight against **"Hidden Hunger"** or **"Micro-nutrition insecurity"** - the term used to describe deficiencies of micro-nutrients and minerals like iron, and vitamins A and C which is widespread in low-income households. They are excellent complementary foods of the first order; more important for man's health than animal products. They are particularly valuable to pregnant and child-bearing women, children and people recovering from illness or suffering from malnutrition for proper reproduction, growth and radiant health. Diets rich in fruits and vegetables during pregnancy are correlated with child's cognitive development, help maintain efficient brain functions and eye health. Iron and vitamins A and C are essential for the optimal development of brain of a child in the first six weeks of conception. Their deficiency during pregnancy causes ailments, blindness and infant and maternal deaths.

Fruit juice is best taken from fresh fruits, not from cans or heated-up and fresh leafy vegetables could be cooked slightly to break down their thick cell walls. Medical experts say fruits and vegetables should be taken on an empty stomach to prevent putridity, burp and stomach bloating, enhance fruit juice to go straight through the stomach into the intestines and stop graying hairs, balding and dark circles under the eyes. This is the secret to beauty, longevity, health, energy and normal body weight.

5.2. Medicines and Health Quality - where Science meets Nature

According to Dr. Hans Martin-Hirt, a German pharmacist, Fr Anselm Adodo, a monk, and late Dr. (Mrs.) Elizabeth Kafaru, an herbal medicine practitioner, horticultural plants are **natural medicine** and **healing power** that provide health benefits in herbal remedies for cardiovascular disease (CVD) (stroke, heart attack and hypertension), and others like hepatitis, cancer, fibroid, infertility, etc. that we treat with orthodox drugs. Fruits and vegetables can be classified as:

5.2.1. Roughage or Fibre Fruits/Vegetables - Fruits and leafy vegetables are a potent source of indigestible dietary fibres which bulk food and help promote peristaltic movement and quickening elimination of waste materials from the colon, thus preventing colon cancer.

5.2.2. Mucilaginous Fruits/Vegetables - Slippery complex substances in Indian spinach, okra, *Corchorus,* waterleaf, bush mango, etc. help bind excess cholesterol, and soothe and facilitate elimination of waste products which are pernicious to the body more comfortably, and protect the gastro-intestinal system.

5.2.3. Bitter Fruits/Vegetables - Bitter-tasting substances in bitterleaf, garden egg and egg plant fruits and leaves, '*Utazi'-Gongronema*, bitter cola, etc. possess anti-inflammatory properties, and are diaphoretic, antipyretic or febrifuge, help depurate the blood of toxins and stimulate liver detoxification, thus preventing fever and dermatitis.

5.2.4. Therapeutic Effects of Horticultural crops

i/ Enlivenment - Flowers are a treasure for depressed minds. It is bliss to have a time at aesthetic places with different kinds of ornamentals and amenities. Medically, they are therapeutic, playing a major role in refining people's minds and elevating their soul above the daily drudgeries. Pot plants and cut flowers enliven rooms and offices, making workers feel happier, brighter and healthier.

ii/ P**reservation/Protection –** Onion, garlic, shallot, basil, ginger and pepper are used as preservative and purification for their powerful smell and pesticidal properties. They help fortify the body with natural antibiotics and anti-tumour substances against micro-organisms causing urinary infections, typhoid fever and dysentery. They also help reduce blood low density lipoprotein (LDL) cholesterol levels and risk of heart attack and stroke.

Tomato, watermelon, grape, red roselle and papaya, etc. are key sources of lycopene and other carotenoids potent antioxidants that increase fertility and provide protection against cancer and CVD. According to a study published in February 17, 1999, issue of the *Journal of the National Cancer Institute*, a diet rich in fresh and processed tomatoes may significantly reduce risk for a variety of cancers such as prostate, lung and stomach cancer, and those of the breast, cervix, colon, esophagus, mouth and pancreas.

In more than two-thirds 72 studies on '*Tomato consumption linked to lower cancer risk'*, people who consumed significant amounts of tomatoes and tomato-based products had high blood lycopene levels and a lower risk of developing several types of cancer. Six healthy male subjects who consumed 60 mg/day lycopene for 3 months had a significant 14% drop in their plasma LDL cholesterol levels, while those who consumed a lycopene-free diet for only 2 weeks had their serum lycopene levels decreased by 50% and ***in vivo*** lipid oxidation increased by 25%.

Consumption of 400 g tin of Heinz cream of tomato soup for only 2 weeks increased lycopene levels significantly by 7-12% and fertility in six men having low sperm lycopene levels at the University of Portsmouth.

iii/ Diuretic (Diuresis) - The minerals in fruits and vegetables cause diuresis; increase considerably the quantity and frequency of urination, lowering urine density and ridding the body of nitrogenous wastes and sodium salts. The alkali properties in them help to neutralize morbid substances and stabilize blood pH resulting from intake of acid-forming foods.

iv/ Laxative – Indigestible dietary fibres and cellulose in fruits and vegetables are laxative aiding smooth digestive tract food passage and easy bowel movement, and the carbohydrates are easily digestible and absorbable into the intestine, thus preventing constipation.

v/ Sedative – Papaya, bitterleaf, roselle, bitter *Solanium*, etc. help induce sedation, thereby preventing sleeplessness which can cause stress, anxiety or some physiological disorder.

Mr. Vice-Chancellor, Sir, the human body is made up of several molecular substances, the presence of which might seem to be an overwhelming threat to our health. But experts say that we would actually not live without them. Apparently, nature is endowed with life-giving antioxidants with their defence mechanisms which help fight off bad molecular compounds and curtail their potential threat to our body. Fruits and vegetables are the greatest natural sources of antioxidants. The potent healing substance rich in pigments and antioxidants that makes fruits and vegetables therapeutic is **Chlorophyll**.

Fruits and vegetables contain vitamins and some other naturally occurring antioxidants like flavonoids that are not present in laboratory manufactured supplements. Human beings cannot produce vitamin C ***in vivo***; they must rely on fruits and vegetables as the main source to meet body requirements. Medical experts indicate high correlation of coronary heart disease with dietary intake of antioxidant, mostly from fruits, vegetables, tea and walnuts. A right relationship with fruits and vegetables is the wisest defence strategy against free radicals.

We readily admit that many Africans staying in rural areas live long and do not suffer from the so called incurable coronary heart disease, which is common in the industrialized nations or among the high-income groups. Why is this so? The rarity of atherosclerosis among indigenous Africans is due mainly to their local diets rich in fresh fruits, vegetables, starchy foods, and red palm oil which reduce LDL cholesterol levels in the blood. Red palm oil is an excellent natural antioxidant source abundantly rich in carotenoid and contains more nutrients than any other dietary oil. In addition to beta-carotene and lycopene, it contains at least 20 other carotenes along with flavonoids, vitamins K, A & E. It is one of the richest natural sources of fat-soluble vitamin E (tocopherol), a super-antioxidant ever known to neutralize oxidative damage of free radicals.

In the Bible, Daniel and his friends purposed not to defile themselves with the royal food, ate nothing but vegetables for ten days; at the end they looked healthier and better nourished (1: 8-15). In Professor E.O. Agbedana's inaugural lecture in 1997 titled, 'Cholesterol and Your Health', parents and children are advised to eat more fruits and vegetables to protect the heart and improve their health. Professor A. O. Falase in his 1981 inaugural lecture titled, 'The Human Heart, Fountain of Life' said:

> ***'And it is fashionable among the elite to condemn our local diet, which has protected us against this terrible disease, hypertension over the years, in preference for the so-called European diet which predisposes to coronary artery disease'.***

According to FAO estimates, it is essential for vital health that at least 30% of our daily food is made up of vegetables. Generally, Africans eat below this. We always wonder why the Chinese stay young. The secret is that China is among high-consumption nations for fruits and vegetables in the world (above 500 g/person/day) and the Chinese take plenty of fruits and vegetable sauces before meals and hot water thereafter. For the same secret, prostate cancer incidence is 120 times greater in the US than in China.

5.3. Domestic and Industrial Disposition

In Africa, fruits and vegetables are produced mainly for domestic markets. In 2006, Ghana and Nigeria exported only 1% mangoes while Cote d'Ivoire exported 7% of the annual quota allocated to Africa by EU. Lack of certification, uniform quality and reliable supply of produce are the main reasons for poor exports from Africa. The last four years have seen remarkable progress in the '**onward march'** of horticultural industry. EU market shares in ACP nations rose from 11% in 2005 to 14% in 2006, West Africa still increasingly attracting buyers' interest.

Citrus, mango and cashew are important raw materials for beverage industries (Table 6). The collapsed canneries for orange factory at Ibadan, Nigeria and tomato factory at Pwalugu, Ghana readily come to mind. Oil palm, coconut and African bush mango for their high seed oil content (70-75%) are used industrially for the manufacture of lubricants, candles, margarine, soaps, mayonnaise, confectioneries, and pharmaceutical preparations (Olasantan 2001a). African indigenous vegetables and spices are important sources of dietary oil, protein and condiments supplies for domestic requirements, and the chemical and food industries to produce different kinds of antioxidant dietary supplements, and pharmaceutical derivatives.

Table 6: Possible industrial and domestic uses of some horticultural crops in Africa

Crop	Domestic use	Industrial use
Citrus	Fresh consumption dessert	Juice for squashes and wines. Essence oils (peel). Animal feed & meals Jelly-marmalade.
Plantain	Fried slices (dodo), chips (ripe)	Flour/bread, biscuits/cakes/Pancake, Baby foods
Banana	Fresh consumption dessert	Baby food, meals, wine/beer
Mango	Fresh consumption	Juice. Slices, powder
Cashew	Fresh consumption	Juice, dried nuts, dye, paints
Cocoa	Juice/wine	Dried beans, powder, butter, Bread, beverages
Kola	Fresh consumption	Cafin, powder, dye, beverages
Pineapple	Fresh consumption	Juice, squash, slices, dried chips.
Guava	Fresh consumption	Juice, marmalade, jelly
Pawpaw	Fresh consumption	Papain tenderizer, enzymes
Amaranths (grain)	Soup, animal feed	Energy producer, confectionery
Okra	Soup, fresh consumption	Cooking oil, powder, dried slice
Melon	Soup	Cooking oil, cake
Roselle	Soup, local (sobo) drink	Fruit (calyces) juice
Ornamental plants	Beautification and purification	Perfumery, cosmetics products, medicinal
Chilli pepper	Soup, fresh/dry consumption	Spice, Condiment, Tear-gas
Onion, garlic, shallot	Soup, condiment	Medicine, composite seasonings

African nations can make a fortune from spices alone. According to an expert, Professor (Mrs.) Mariappa Vasundhara at the University of Agricultural Science, Bangalore, India in her lecture “Prospects of Spice Research and Production: The India Example” at the first National stake holders workshop on spices at NIHORT, Ibadan in December 2-3, 2008:

Nigeria can generate foreign exchange if it harnesses opportunities at her disposal by producing various spices for export. Nigeria is blessed with more fertile land than India, which earned foreign exchange estimated at $2.5bn annually from spice export to over 150 countries. India is currently growing and processing about 50 different varieties of spices for domestic consumption and export. Nigeria has enough fertile land that could accommodate more than 50 species of spices.

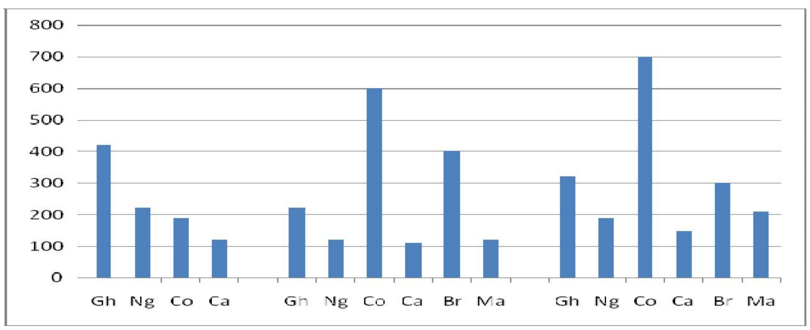
We can readily agree with Professor Vasundhara that Nigeria and other African nations can still do more in the production of spices for their domestic and export markets. However, African nations do not often back up their good intention in agricultural policy with good implementation commitments. According to Ker (1996), poor Africa’s economic growth rates are attributed to:

Africa is littered with poorly planned and executed agricultural projects that achieve little and often eventually fail completely. Instead of publishing the results and trying to learn from these failures, they are often conveniently forgotten so that the same mistake is made in the same area by a similar project within 5-10 years.

5.4. Trade/Economic value

Mr. Vice-Chancellor, Sir, the economy of most West, Central and East Africa nations, before and after their independence, depended largely on horticulture. For example, the colonial authorities of Nigeria, Ghana, Cote d’Ivoire and Kenya realized the importance of cocoa, kola, oil palm, coffee and tea to the economy of these nations by establishing research institutes to promote the production and other scientific aspects of these tree crops. In Nigeria, their products contributed largely to foreign exchange earnings, leading to rapid material and educational development before the advent of petroleum.

In the 50s-70s, the products from cocoa and oil palm accounted for over 60% of the GDP from primary production agricultural sector, and over 40% of the market shares from total exports of Nigeria, Ghana and Cote d'Ivoire. Cocoa has been the main export crop and a major source of foreign exchange and domestic income earner. Ghana, Nigeria and Cote d'Ivoire are the leading cocoa-producers in Africa, with Ghana and Nigeria formerly the world largest export producers. However, with concerted efforts, Cote d'Ivoire dramatically rose to be the leading world export producer of cocoa since 1986 (Fig. 2). The inflow of $8-15 million foreign exchange from palm products in Nigeria or Ghana is insignificant compared with over $19 billion realized from the same products in 2008 in Malaysia or Indonesia, currently the two world largest export producers of palm products.



1969/70 1985/86 1989/90

Figure 2: Cocoa production (t/year) by leading cocoa-producing countries in the world
Gh=Ghana; Ng=Nigeria; Co=Cote d'Ivoire; Ca=Cameroon; Br=Brazil; Ma=Malaysia

Table 7: Exportable horticultural crops grown in Africa

Fruits	Vegetables	Spices	Ornamentals
Plantain	Okra	Occimum	Orchids
Banana	Bitter leaf	Xylopia	Roses
Grape fruit	Water melon	Parkia	Aloe
Oranges	Onion	Garlic	Ferns
Mango	Tomato	Chilli pepper	Strelitzia
Cashew	Amaranths	*Piper nigrum*	Proteas
Papaya	Celosia	Ginger	Heliconias
Pineapple	Corchorus		Anthuriums,
Cocoa	Roselle		Chrysanthemum
Kola	Garden eggs		
Tea	"Egusi" melon		

In the 60s, Nigeria pioneered export of orange and pepper from West Africa to Europe, but in the last three decades new African exporters, including South Africa, Zimbabwe, Kenya, Ghana, and

Cote d'Ivoire have beaten Nigeria to it due to her strong linkages with crude oil. The new comers intensified efforts to promote exports of fruits, vegetables, spices, cut-flowers and ornamentals (Tables 7).

Organic fruits and vegetables are a clear reality, fast growing economic sector at present in East and South Africa. Certified organic lands in Africa cover about 891,000 ha, involving cocoa, coffee, fruits and spices, and Kenya, Uganda and Tunisia have the biggest organic certified farms. In Sao Tome and Principe, about 1200 farmers are engaged in organic cocoa cultivation, and they produced 200 tonnes of organic cocoa in 2007.

All over the world, floriculture is characterized as a sector experiencing rapid growth due to income development and globalization. In Africa, export market for floriculture has grown over the last 5-10 years at an average of 5% yearly and popular sellers among them include roses, orchids, ferns, daisy (*Chrysanthemum*), and carnations. Export from West Africa is very limited at the moment. Export from North Africa focused mainly on roses and carnations. More significant export growth is from Central, East and South Africa, accounting for about 90% of the total export from Africa.

The Netherlands is the world largest producers and exporter of ornamental plants and cut flowers (45-55% of the world market share), Africa represents only 8%. Kenya, which originally is a tea and coffee producer, remains the clear leader and the major export markets are EU. The first cut-flower nurseries were established in 1969 but in 2002/3, Kenya increased her already substantial market share of EU exports by 17%. She is the largest exporter of cut flowers, representing 60% of the African market; Zimbabwe is the second largest exporter with about 20%, followed by Morocco and South Africa. Although it was established in 1972, Kenya's floriculture industry accounted for about 25% of the economy; ranking among the largest income earners; tea and coffee. Kenya realizes $750-1000 million yearly from floriculture. Other promising nations are Zambia, Malawi, Tanzania, Uganda and Ethiopia, most spectacularly Ethiopia which put up a massive growth of 23% in 2007/8.

Africa has comparative advantages for producing flowers, because of availability of land, water and labour, favourable climate and preferential tariffs with the EU. Some growers have introduced new production technology. Ugandan growers use hydroponics, a technique which limits pests and diseases to grow flowers. Farmers in Zambia have switched from maize to highly priced roses. South Africa growers have found a profitable market for daisy. North African nations, which originally produced roses, have shifted to carnations. The Sarius

Palmetum/Botanic Garden in Nigeria, led by Dr. (Mrs.) Ajoke Mohammed, specializes in indigenous ornamental palms.

5.5. Job Opportunities in Horticulture

Horticulture has undoubtedly generated employment in Africa, thus assisting in reducing poverty and creating wealth (Norman 1998). Many people are engaged in the primary and secondary sectors of horticulture. Though available statistics are not accurate:

● Approximately 10 million Ghanaians, 40 million Nigerians and 5 million people in Cote d'Ivoire benefit directly or indirectly from foreign exchange derived from cocoa industry. Over 5 million people in West Africa and hundreds of thousands of people in Central, East and South African are employed in production and marketing of vegetables, fruits and ornamentals.

● People are engaged in landscaping, floriculture and amenity provisions which are becoming more popular and lucrative in Africa due to the unprecedented increase in urbanization.

● Pot and cut flowers used in floral arrangements by florists for bouquets, corsages, wreaths and boutonnieres, and for decorations in homes, public buildings and functions have led to the establishment of more small-scale floriculture and flower-pot industries as labour employers.

● Organic agricultural sector employs about 130,000 farmers in 24 African countries; Uganda, Tanzania and Kenya have the world's biggest number of organic farmers.

● Ministries of agriculture, departments of parks/gardens, commercial farms and banks, agro-processing companies, secondary schools, colleges of education, research institutes and universities have recruited horticulturists in their establishments.

Mr. Vice-Chancellor, Sir, I will now end this section of the inaugural lecture with the publication "Nigeria's agricultural assets more powerful than oil" of the Director General of the Ibadan-based IITA, Dr. Peter Hartmann on the occasion of World Food Day in Ibadan in the Sunday Punch October 19, 2008 thus:

> ***Nigeria, Africa's largest oil producer, has agricultural assets that are more powerful than oil. Nigeria and other African nations should tap the opportunity presented by the current food crisis. Africa is well-placed to make the most of this crisis. It has the agricultural resources that are more powerful than oil to come out of this situation better than it was before. Nigeria and other African nations have the technologies, elevations, ecosystems, arable lands, and yield gaps that can be exploited. These are very powerful potential assets that other continents do not have.***

6.0. MY ACADEMIC CONTRIBUTIONS IN HORTICULTURE

Mr. Vice-Chancellor, Sir, I want next to talk briefly about research efforts I have made with my collaborators in physiology of vegetable crops and farming systems horticulture. My duties and challenges here stand clear.

i/ Manpower development in horticulture and related areas in agriculture.

ii/ Working with scientists and agencies nationally and internationally for horticulture development projects and programmes.

iii/ Carrying out research and provide information on Farming Systems Horticulture, and phenology/physiology of horticultural crops.

For capacity building, courses in agriculture and horticulture have been developed for Colleges of Education, undergraduates and postgraduate students up to Ph.D level. Several of the products are working in educational, commercial and private sectors, and employers of labour.

We are collaborating with research institutes and establishments such as ITTA, NIHORT, ADPs, and individual farmers in South-West Nigeria. My collaboration with IITA assisted in my Ph.D degree programme. With farmers, afforded the opportunity to quantify and put into the literature production technologies in rain-fed and out-of-season vegetable crops. We are also collaborating with other international scientists in America and Europe.

For research development, the quantitative study of intercropping is recent and most of the literature was published after the mid sixties. The system was ignored as if there is no sense in it. One reason is that after the second world war, food crop research in the tropics concentrated mainly on the transfer of temperate zone monoculture technology. For instance, it was after the heinous apartheid regime collapsed in 1994 that the first research studies into intercropping were carried out in South Africa (Lucas 2007). Scientists thought that success in crop production in the tropics could only be measured against a temperate region model. Crop improvement and production technology which work successfully for monoculture were simply transferred to mixed systems.

Scientists now face the stark reality that intercropping which occupies over 75% of the total arable land in the tropics has sustained small-scale farmers for centuries. The reasons for the popularity of intercropping have been discussed (Finlay 1975, Steiner 1984). But one important reason intercropping is popular in the tropics is that it is more stable than monoculture. In Africa and South Asia, where environmental stress is common, intercropping is an insurance against total crop failure, and the stability under it is attributed to the partial restoration of diversity lost under sole cropping. Disadvantages are mainly related to the use of modern agricultural inputs such as synthetic fertilizers and pesticides. Mechanized crop maintenance and harvesting may be difficult or impossible. According to Professor E.O. Lucas in his inaugural lecture in 2007 titled ‘Too much food for thought, but very little for the table’, we need to salute our African farmers for being pertinacious, who have through the years toiled with local tools so that food, including fruits and vegetables get to our table.

In the last 3-4 decades, research into intercropping has advanced into a respectable standard of agronomic research with several new analytical tools and a considerable volume of results. The efforts of Professors Bede Okigbo, A.A. Agboola and T.A.T. Wahua (Nigeria), R.W. Willey and D.S.O. Osiru (Uganda) generated exclusive interests in intercropping. These gem scientists for years conducted research into intercropping mainly involving food crops. I was able to follow their indelible efforts by evolving the Farming Systems Horticulture.

6.1. Sustainability Perspectives of African Agriculture

According to Duesterhaus (1990), sustainable cropping systems are capable of making productivity to continue to exist. Such systems must be resource conserving, commercially competitive, socially and environmentally supportive. Agriculture in African is increasingly threatened by limited arable lands/water resources, rapid demographic growth, and shifting agro-ecological systems caused by climate change. Degradation of soil and its ability to retain water and nutrients are a particular problem for concern in Africa. The thin layer of soil that remains is fragile and quickly washes away when exposed to heavy tropical rains and water erosion; an annual average of 30 kg/ha of nutrients is lost in about 85% of arable land. By 2050, African population is expected to rise to about 1.7 billion, and about 300 million hectares of arable lands are expected to be cultivated in the world to achieve just 1% increase in annual productivity.

There is no doubt that governments, farmers and scientists concerned with the problems of food crisis in Africa need models of sustainable farming systems that combine elements of traditional and conventional technologies. This is where and why I come in. To be able to further appreciate my contributions, we shall briefly examine ecological benefits of vegetable crops and their related sustainability in African agriculture.

6.2. Ecological Attributes of Vegetable Crops in Mixed Systems

6.2.1. Agro-Ecological Benefits

There are good agro-ecological reasons in Africa why intercropping is preferred by small farmers even if its biological efficiency is not superior to that of solecropping. This is such a situation when there is no real practical sole-crop alternative. In the Sahelian climate of Africa with unimodal pattern of rainfall below 500 mm, simultaneous planting is practised with high density of short-duration food and vegetable crops of similar or differing maturity for product diversity. Farmers have only one rain-fed cropping season, a second season crop is practically not possible in such agro-ecology without irrigation. The unimodal rain-fed food and vegetable mixtures would therefore be the best choice, even if there were no biological benefits

In the humid West Africa, farmers seldom plant vegetables alone, they usually plant them with maize, yams, cassava or plantain in the first season. The vegetables are harvested during the short break in the rains after which the food crops continue to grow alone. A second season vegetable crop in the same plot may not be attractive because of shading from the food crops. Other second season options may also have several drawbacks because of unpredictable weather conditions or high disease or insect pressure. The combination of food with vegetable crops for product diversity in the early season would therefore be the best practice, even if there were no much biological advantage.

6.2.2. Modification of Soil Hydrothermal Regime

Another issue has been modification of micro-environment. For a long time now, cropping season has become characterized by drought, intense heat, supra-optimal temperatures and erosion which often lead to reduction in crop yield and thereby increase risk. One of the most well illustrated advantages of intercropping is reduced abiotic stress. One crop may serve as a live-mulch whereby it improves soil resource use and growth of the other crop, making it less susceptible to drought, erosion and insolation or heat. The **Bio-protector Technology (BpT)** is that one crop provides cover over the soil and reduces moisture and heat stress conditions that would otherwise have affected the growth of the other crop. Broad-leaf and spreading-canopy vegetable crops like melon, pumpkin and okra are the first set of vegetable crops often planted with food crops as they provide ground-cover and improve soil moisture for the food crops.

In a series of research studies, simulating farmer practices under the prevailing conditions at the University of Ibadan, IITA, Ila-Orangun and Abeokuta, Nigeria, vegetables were mixed with food crops as they satisfied the **BpT**; reduced soil temperatures and increased moisture content. We found that the diurnal soil temperatures at 5 & 10 cm depths were 1.2-8.1 ^{o}C cooler and soil moisture content 10-62 g kg^{-1} greater, on average, in maize/ melon, maize/okra, cassava/okra, cassava/pepper, and yam/pumpkin mixtures than the pure control plots. Soil temperatures and moisture content were highly correlated by 56-79% with pumpkin LAI. The vegetable crops modified soil micro-environment of the food crops more in the drying than wet conditions, and under varied planting dates than stand densities (Olasantan 1988a, 2001b, 2007; Olasantan & Bello 2004; Olasantan, Salau & Onuh 2007) (Table 8).

Table 8: Effect of melon sowing date on soil temperature, moisture content and rhizosphere fungi and bacterial counts of intercropped maize, cassava and melon in 2002 and 2003 in Nigeria

		Soil temperature (°C)		Soil moisture (g/kg)		Fungi (x 10^4 CFU/g)		Bacteria (x 10^4 CFU/g)	
2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
		8+	12	8	12	8	12	8	12
Sole crop maize		32.8	37.1	117	102	117	113	197	203
Sole crop cassava		37.7	38.1	102	105	123	118	163	195
Sole crop melon									
28 Aug.	–	27.5	–	137	–	–	–	–	–
11 Sept.	20 Sept.	28.7	28.5	105	115	116	116	219	123
25 Sept.	4 Oct.	29.2	29.7	88	80	107	92	131	104
Maize/melon intercrop									
28 Aug.	–	28.5	–	129	–	–	–	–	–
11 Sept.	20 Sept.	29.0	29.2	116	120	135	128	254	250
25 Sept.	4 Oct.	29.2	30.0	103	75	124	104	251	161
Cassava/melon intercrop									
28 Aug.	–	28.3	–	135	–	–	–	–	–
11 Sept.	20 Sept.	28.5	28.9	114	125	209	186	279	349
25 Sept.	4 Oct.	28.5	27.7	95	95	156	134	188	208
S.E (20 D.F)	(14 D.F.)	0.36	0.50	4.8	6.4	10.9	9.4	15.6	17.6

+ Weeks after sowing. *Source:* Olasantan & Babalola (2007)

6.2.3. Modification of Soil Physico-Chemical Properties

Adoption of the **BpT** with spreading and broad-leaf vegetable crops, and creeping grain legumes provided not only cool and moist soil environment, but also enhanced soil microbial diversity, as they also improved soil nutrient conservation. Intercropping cassava or maize with tomato, melon or cowpea increased water infiltration rate, reduced water run-off by 76% and improved soil particle size distribution, bulk density, CEC, pH, exchangeable cations, organic C, N and P (Olasantan 1985, 1988a & b; Hulugalle, Ezumah & Leguman 1994; Olasantan, Ezumah & Lucas 1996; Olasantan & Babalola 2007).

6.2.4. Modification of Rhizosphere Organism Activities

Micro-organism diversity in intercropping is yet to be exploited fully by the scientific world. Soil organisms have a role in facilitating nutrient transfer to crops, and the association becomes gratifying where mixture components protect the soil and have different rooting depths. With the **BpT**, pepper, okra and pumpkin were planted with yams or cassava as they increased earthworm casts by 20-40%. Melon increased the rhizosphere bacterial and fungi counts with greater values occurring in association with cassava (36-49%) than maize (5-29%) (Table 8).

The relationships between rhizosphere organisms and hydrothermal elements were quantified. We found that in yam/pumpkin intercrop 96-98% of the variation in earthworm casts was accounted for by the variation in soil temperatures or moisture content (Table 9). In cassava/melon or maize/melon association, 41-77 and 23-42% of the variation in the rhizosphere fungi or bacterial counts were accounted for by the variation in soil moisture and temperatures, respectively. Also, variation of 51-61% in tuber yield of cassava and 69-98% in grain yield of maize was accounted for by the variation in soil temperature and moisture content. Maize was mixed with cowpea or melon, uptake of N by melon was correlated with rhizosphere bacterial counts (Wahua 1984; Olasantan 1988b; Olasantan & Babalola 2007).

Table 9: Correlation analysis between hydrothermal variables and leaf area index of pumpkin (LAI), earthworm casts and yam tuber yield at Abokuta, Nigeria

Variables	LAI(n = 18)	Earthworm casts (no. m^{-2}) (n = 12)	Tuber yield (t ha^{-1}) (n = 18)
Experiment 1			
Soil temperature (^oC)			
Soil moisture content (g kg^{-1})	–0.77**	–0.89**	–0.96**
Dry weed biomass (g m^{-2})	0.79**	0.99**	0.79**
Experiment 2	–0.89**	–	–
Soil temperature (^oC)			
Soil moisture content (g kg^{-1})	–0.59*	–0.97**	–0.99**
Dry weed biomass (g m^{-2})	0.56*	0.96**	0.99**
	–0.76**	–	–

*and **significant at P< 0.05 and P < 0,01, respectively. *Source:* Olasantan (2007)

6.2.5. Weed Management

Mr. Vice-Chancellor, Sir, the most well documented advantage of intercropping is reduced damage from weeds, insects and diseases. This is partly due to high diverse insect and weed community in mixtures that enhance greater pest predators. Globally, problems associated with agro-chemical use and recent renewed interest in organic foods had focused attention on the use of other environmentally safe technologies. Despite the substantial pesticide use, crop yields continue to be threatened by pests. Reasons include built-up pesticide resistance, outbreaks of secondary pests, and susceptibility in the crop plants. As these and other problems with monoculture become more apparent, sustainability is becoming imperative, and interest in intercropping is growing, as possibly, part of the solution to pest management in the tropics.

Mixture of food and vegetable crops alleviates weed problem as the vegetable crops form major ground canopy storey. Widely spaced inter-rows and slow initial growth of cassava or yam allow space for weed build-up, and interplanted vegetables effectively replace weeds. Using the **BpT** mentioned above in association of okra, melon or pumpkin with maize, yam or cassava weed biomass was reduced by 22-67% and frequency of weeding by 33-75%. Only one or two weedings in the associations but thrice in maize and four times in yam or cassava grown alone. Variation in pumpkin LAI accounted for 76-89% of the variation in weed biomass in mixture with yam (Table 10). The effectiveness of the vegetable crops in improving soil micro-environment and in reducing weed infestation is pumpkin>melon>okra>pepper.

Application of **BpT** implies good protective or covering mechanism of vegetable crops, especially the spreading and broad-leaf types, to adapt to abiotic stress conditions. They are often included in mixed systems for their ecological benefits besides the yields they provide.

i/ a live-mulch to provide ground cover against supra-optimal temperatures and to conserve rhizosphere organisms and moisture, making water and nutrients available for crop growth.

ii/ a cover-intercrop either to provide a reduced space for weeds to grow and get a foothold or reduce weed biomass through competition or allelopathy.

These findings raised some pertinent questions:

i/ Does the melon/pumpkin rhizosphere harbor or increase populations of N-fixing bacteria?

ii/ Are there other soil micro-organisms in the rhizosphere of these spreading cucurbits that promote availability and uptake of nutrients?

iii/ Do vegetable crops, especially broad leaf and spreading types, contribute to the redistribution of water and nutrients in crop species association?

iv/ Can the protective mechanism of the spreading and broad leaf vegetable crops with high leaf-area index (LAI), dry matter accumulation, and residue deposits partly solve the nutrient/ water conservation and weed growth dilemmas, and other shifting agro-ecological systems caused by climate change experienced in tropical Africa?

Hence, microbial organisms and more of such spreading and broad-leaf vegetable crops should be identified, investigate in details, and encouraged their use in ecological stability and yield improvement in African agriculture. The **BpT** was introduced into the literature for the first time by Olasantan (1988a). Mr. Vice-Chancellor, Sir, this is one of my most important academic contributions in the field of Farming Systems Horticulture.

6.2.6. Insect Pest and Disease Management

A further reason why farmers prefer intercropping vegetables is risk reduction. Staple and vegetable crops have different pest and disease complexes and growth requirements. They are not susceptible to the same parasites and can provide durable ecological protection against pests and diseases seeking host weeds and crop plants. When one crop fails, the other may still survive. Our contributions in pest management were based on **Trap Hypothesis (TH)**. One crop may serve as a deterrent or disruptive mechanism whereby it alters the quality of the other crop, making it a less attractive host for a predator or a parasite. The **TH** is that one crop attracts pests that would otherwise have gone to what is being grown as the principal or major crops. Cassava or yam was grown with okra as they provided durable ecological protection and masked the okra smell for okra leaf beetles. Leaf damage caused by flea beetles (*Podagrica* spp.) and root-galls caused by nematode (*Meloidogyne* spp.) were reduced by 20-37% in okra grown with cassava or yams (Olasantan 2001b; Olasantan & Agbogun 2008).

Table 10: Effects of frequency and severity of leaf removal and pruning on yield characters of okra at Ila-Orangun and Abeokuta, Nigeria

	Frequency of young leaf removal				
Variables	Nil	3-weekly	2-weekly	1-weekly	S.E.
	Five weeks after sowing				
No. of fruits/plant	9.6	9.5	7.6	6.7	0.72
Weight/fruit (g)	18.7	18.2	19.7	18.0	0.38
Fruit yield (t/ha)	6.8	6.5	5.9	4.4	0.53
	Seven weeks after sowing				
No. of fruits/plant	9.7	9.6	7.7	6.8	0.72
Weight/fruit (g)	18.3	17.8	18.6	17.8	0.20
Fruit yield (t/ha)	6.4	6.3	5.6	4.1	0.53
	Severity of leaf removal				
	Nil	1	2	3	S.E.
	Young leaves removed				
No. of fruits/plant	11.3	11.7	9.0	7.2	1.05
Weight/fruit (g)	15.0	14.8	14.6	13.4	0.36
Fruit yield (t/ha)	8.2	8.0	6.3	4.6	0.84
	Fully expanded whole leaves removed				
No. of fruits/plant	7.8	8.0	6.7	5.3	0.62
Weight/fruit (g)	15.1	14.9	13.9	14.5	0.26
Fruit yield (t/ha)	6.6	6.9	4.7	3.7	0.77
	Proportion of leaf tissue removed				
	Nil	¼	½	¾	S.E.
No. of fruits/plant	10.2	10.0	7.9	6.0	1.00
Weight/fruit (g)	15.2	15.5	13.8	13.2	0.55
Fruit yield (t/ha	7.2	7.0	5.3	3.9	0.78
	Pruning				
	Nil	¼	½	¾	S.E.
Shoot dry weight (g/plant)	176	194	235	151	9.7
No. of fruits/plant	11	13	15	12	0.50
Fruit yield (t/ha)	6.5	9.1	10.1	7.1	0.56

Source: Olasantan (1988c), Olasantan and Salau (2008)

Additional contributions in pest management were based on **Damage Frequency and Severity Hypothesis (DFSH)**, in which the rate of occurrence and the extent of leaf area damage in vegetable crops caused by insect pests before any substantial yield loss occurred were quantified. Using the **DFSH** on okra, pumpkin and cocoyam, various proportions of their apical buds or shoots, young folded or fully expanded leaves, and branches were removed, simulating insect pest damage and/or leaf harvest. We found that when the apical buds and single leaves at 3-weekly intervals or a quarter of the leaf area or half of the upper foliage in okra, young-folded leaves in cocoyam at 3-weekly intervals, and 30-cm long apical shoots in pumpkin at 1½–2-weekly intervals were removed the vegetable crops tolerated slight reduction in their leaf areas without any substantial loss of yields (Olasantan 1986, 1988c, 1990, 2006; Olasantan & Salau 2008) (Tables 10). The implication is that slight defoliation (less than 25%) in leaf area of these vegetables during growth, as can happen with insect damage and/or human harvest, may not be detrimental to their production.

6.3. Phenology of Vegetables in Mixed Systems

There are questions as to how light interception, LAI, water or nutrient absorption and utilization, and assimilate partitioning change in vegetable crops grown in mixtures. In our work, we found that if the leaf areas of okra, cocoyam and pumpkin were reduced by less than 25%, we could improve light interception and enhance their yields. Shoot dry weight and pod yields of okra, for instance, increased by 10-34 and 40-55%, respectively, when a quarter or half of its upper foliage was pruned. Pruning also increased specific leaf area and enhanced greater okra pod yield than removing of various proportions of its leaf tissues (Table 10). Pruning has direct implication in light interception and leaf water potential of the vegetables.

The phenological period between the times of planting and harvesting was similar in okra grown in sole and mixed stands with yam or cassava, but it was 6-8 days earlier in the late than early-season in both systems. Okra and pepper reached flowering stage 6-9 and 2-5 days earlier, respectively, in association with cassava than the sole okra or pepper control plot. Earliness to harvesting has implication in early-market high prices.

The **Harvest Proportion (HP)** in which the daily or weekly percent yield relative to total yield was proposed as a guide for vegetable growers. The **HP** is that relative market prices of vegetable crops in a given area could serve as a strategy in staggering or synchronizing vegetable crop production, either by advancing planting and harvesting dates or spreading harvest period to catch early or late-market high prices. Producers who keep track of market prices stand to protect their commodities and make more money. The **HP** can be determined in a given cropping system and season at a given location, and generalized for vegetable crops whose edible leaves, fruits and roots are usually harvested over a length of time. In such type of vegetable crops, it is not only the total yield at a time that is most valuable to farmers, but also the yield at the peak of market price. The formula is:

$$HP = \frac{Wy\ (t\ ha^{-1})}{Ty\ (t\ ha^{-1})} \times 100$$

where HP = harvest proportion of daily or weekly yield
Wy = daily or weekly fruit yield in t ha^{-1}
Ty = total fruit yield t ha^{-1}

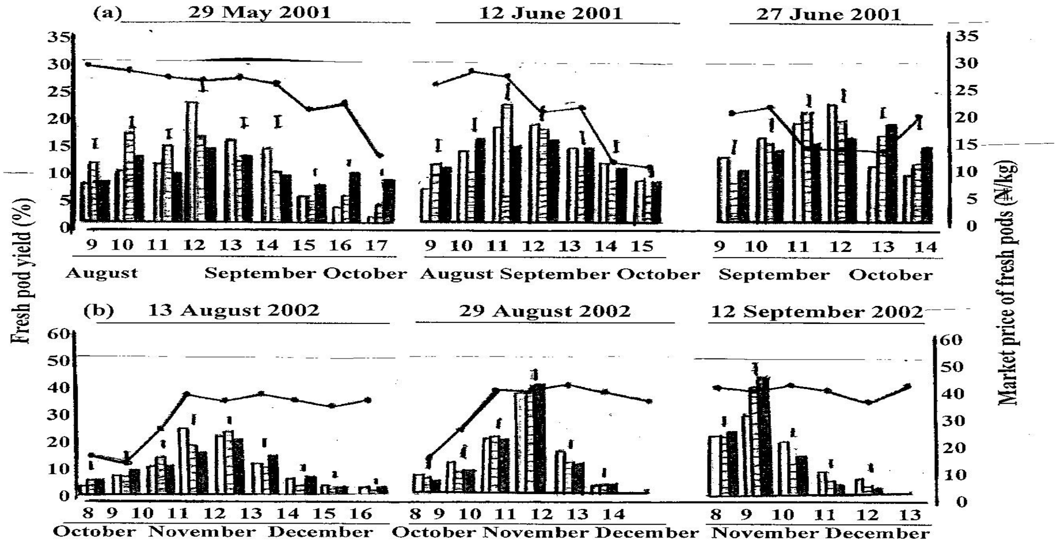


Fig. 3. Weeekly fresh pod yield (%) of okra grown at different sowing dates in monoculture (□) and mixtures with cassava cv. TMS 30752 (H) and cassava cv. Odongbo (■) and weekly market price of fresh pod of okra (•—•) in (a0 2001 and (b) 2002. Bars are s.e.of means (Source: Olasantan & Olowe, 2006)

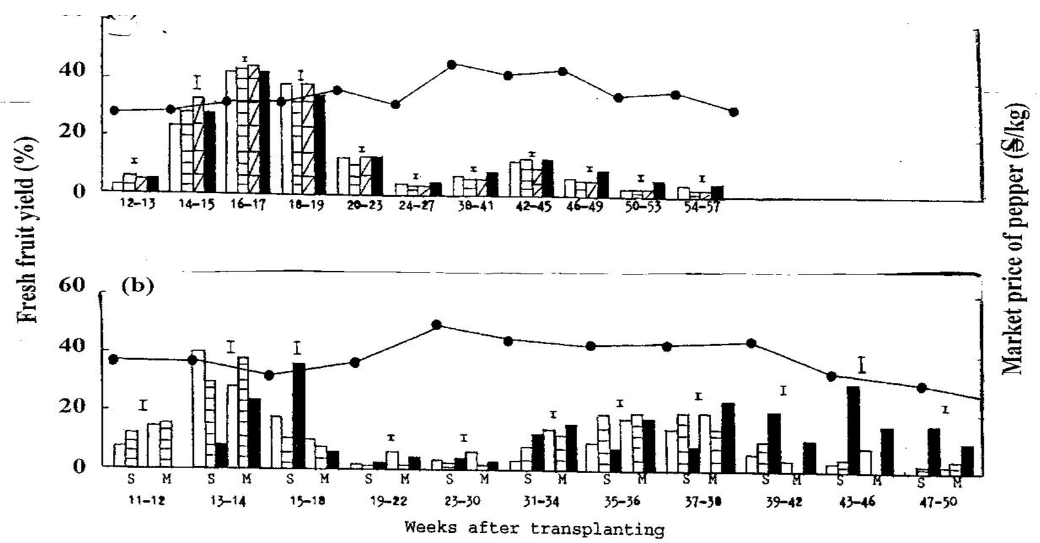


Fig. 4. Fresh fruit yield and market price (•) of pepper during the and second flushes in sole pepper (□), Odonbgo/pepper (H), Idileru/pepper (Ĭ), TMS 30572/pepper (■) in (a) Expt. 1 and Tatase (□), Sombo (H), Atarodo (■) in sole (S) and mixture (M) in (b) Expt.2. Bars are s.e. of means (*Source*: Olasantan et al., 2007)

The concept was used for okra (Olasantan 1999b; Olasantan 2001b; Olasantan & Bello 2004; Olasantan & Olowe 2006) (Fig. 3) and pepper (Olasantan, Salau & Onuh 2007) (Fig. 4), using the Ogun State Agro-Statistics Reports 1997-2002 market prices. As shown in Figs. 3 & 4, there is a low price and a glut on the market for vegetable crops if the curve for market price remains or falls below the percent yield curves or bars. Contrarily, there is a high price and no glut on the market if the curve for market price crosses or remains above the maximum percent yield curves or bars. Using the **HP**, there is likelihood of a glut on the market for okra in October and November and for pepper in November and early December. Fresh tomato, pepper, and okra fruits attract high market prices in February to June. Mr. Vice-Chancellor, Sir, this is another aspect of my most valuable contributions in Horticulture.

7.0. THREATS TO HORTICULTURAL CROPS IN AFRICA

Mr. Vice-Chancellor, Sir, we have gone this far to show that horticulture is indeed a goldmine that can be used as bedrock of national development in Africa. However, biodiversity of these essential plants are threatened seriously by natural processes and human activities. FAO estimates show that some 75% of the genetic diversity of wild and cultivated varieties has been lost worldwide through these forces, particularly in the tropics.

7.1. Natural Processes

Biodiversity erosion caused by natural processes is due mainly to climate change, including drought, desertification, erosion and extreme temperatures within evolutionary time scale. However, the effect of natural processes is occurring much faster because of human activities.

7.2. Human Activities

Human activities that accelerate loss of genetic diversity of horticultural crops are directly associated with the introduction of modern varieties and socio-ecological factors.

7.2.1. Introduction of Modern Horticultural Crop Varieties

The main human activity causing diminution of indigenous crop varieties is the introduction of modern varieties which was most considerable in the 20th century. The implications are:

i/ Many farmers have abandoned indigenous varieties and their landraces which naturally tackle climate change and guard against uniformity of cultivated varieties. At the same time, vast areas of farmlands are now planted to modern horticultural crops. A stranger coming to Africa for the first time and probably stay in cities would think that exotic vegetable crops are the main vegetables eaten by Africans. Schippers (2000) stated thus:

> ***"After living in Zambia, Kenya, Tanzania and Egypt for well over 20 years, working as a horticulturist, I would not have hesitated to cite tomatoes, cabbages, carrots, onions and other vegetables that are used by Europeans as being the main vegetables eaten by African people. It took me several more years and extensive travel in West***

and Central Africa to come to realize that this may not be entirely correct, and that there are many different vegetables which are commonly eaten by people in Africa's rural areas and not seen at the main city markets".

ii/ Many farmers have also abandoned the age-old practice of mixed cropping which normally serves as an insurance against adverse abiotic and biotic conditions and crop failure.

iii/ Production of modern varieties can only be met where external inputs like synthetic fertilizers and pesticides are available and wherever environmental conditions are suitable.

iv/ Introduction of exotic crops brought indiscriminate use of agro-chemicals, causing serious environmental problems; surface and ground water pollutions, soil acidification, ammonia volatilization, and anthropogenic greenhouse gas emission, and threat to human health. In 2005, N-fertilizer use alone accounted for about 60% of the emitted nitrous oxide, which has far greater global warming impact and traps 300 times more heat than carbon dioxide.

7.2.2. Socio-ecological factors

Socio-ecological forces associated with the demographic growth lies at the heart of the threats to African agriculture. Population growth rate of 5.3%/year Africa has been regarded as the highest rate in the world and is expected to rise by over 10 million young people yearly and the figure will be more than double in 2020. The consequences are more intensive cultivation, deforestation, and over exploitation of all natural resources, and extensive degradation of the environment giving rise to desertification, destruction of natural habitats and biodiversity, and rapid exploitation of fruits, vegetables and geophytes (rhizomes, roots, tubers, corms and bulbs) which makes them highly vulnerable to extinction.

Mr. Vice-Chancellor, Sir, besides climate change, African indigenous horticultural crop varieties are presently seriously faced with two dangers:

i/ The struggle to provide enough food for fast-growing population, modern horticultural crop varieties will displace indigenous ones.

ii/ The knowledge of how to cultivate, conserve, process and use African indigenous horticultural crops may die out even before the crops themselves disappear.

8.0. STRATEGIES FOR SUSTAINABLE CONSERVATION OF HORTICULTURAL CROPS

Having identified factors threatening horticultural crops in Africa, the question is: What are the appropriate strategies to conserve and prevent them from going into extinction? Such strategies must be sustainable, environmentally compatible, economically reasonable and socio-culturally acceptable. Such strategies must also have some promulgated protective legal elements for sustainable conservation and exploitation of horticultural crops like in wildlife.

i/ To limit or stop importation of temperate fruit and vegetable products to Africa.

ii/ To recognize medicinal/herbal values of indigenous horticultural crops.

iii/ To encourage production, industrial processing and exporting potentials of indigenous horticultural products in Africa like India and China in recent years.

8.1. *Ex-situ* Conservation

The center for International Plant Genetic Resources Institutes, Rome, Italy works with countries all over the world, largely concentrates on ***ex-situ*** approach. The center helps establish national and regional gene-banks and provides supports for their activities. ***Ex-situ*** conservation is a major institutional line of defence against the genetic erosion of most important genetic resources. In 2009, an international treaty agreed to create a global gene pool to preserve genetic variety in food crops that is being lost to extinction with the view to supporting conservation of genetic materials in developing nations of the world.

Major problems of an ***ex-situ*** gene-bank in Africa are:

i/ the number of taxa involved is gigantic and many of the species are poorly identified taxonomically, let alone in terms of their genetic diversity, names, characterization and evaluation data, including yield traits, quality, phenology and reactions to climatic stress.

ii/ African peculiar problems; lack of timely, reliability and long-term financing, appropriate equipment for gene-bank, and stable supply of electricity.

8.2. *In-situ* Conservation

The United Nation Convention on biodiversity describes ***in-situ*** conservation technique as, "The conservation of ecosystems and natural habitats, and the maintenance and recovery of viable species in their natural or original environment where they have developed their distinctive properties, and always evolved their own strategies for resisting insect pests, diseases and bad weather". ***In-situ*** approach helps to preserve the ecosystem as an invaluable natural reservoir for desirable genetic materials.

8.3. Mixed Systems Conservation

Mixed cropping is an important key for **on-farm** conservation of crop genetic resources. It allows for many crop species to be conserved under natural conditions that make them to continue to evolve. Technically, mixed cropping is important in the conservation and evolution of crop plants. It is the cheapest practicable means of involving small farmers actively in the production of traditional varieties and conservation of their genetic materials.

8.4. Agronomy of Mixtures with Vegetables

There is only one effective way to conserve genetic materials of traditional varieties **on-farm**; we must involve mixed cropping systems. Mr. Vice-Chancellor, Sir, there is no way to effectively improve vegetable production in Africa without involving intercropping. However, the number of intercropping advantages derivable in a specified situation and the extent to which they can be maximized in Africa depend on several factors. My duty, as a farming systems horticulturist, is to study several intercropping situations in diverse agro-ecologies and come up with recommendations to maximize the derivable biological advantages.

There is no way in which the interacting factors in intercropping could properly be evaluated to improve vegetable production without involving related research methods. It was part of our work to evolve experimental designs and field lay-outs of respectable agronomic standards with simple statistical applications. We used parametric statistics for factors that were tested and parameters taken on vegetable crops grown in sole and mixed stands (Wahua 1999). The statistical procedures and systematic approaches introduced into intercropping vegetable crops have been the secret of our research studies and commended internationally, they are being used in Africa and other tropical nations of the world.

The nature of tropical farms is characterised by factors which have implication in crop conservation (Olasantan 1992, 1999a). Before intercropping can be widely adopted for conventional farming, considerably more precise agronomic rules, including selection and combination of appropriate varieties, spacing, population, planting geometry, sowing date and nutrient requirements are needed. Mr. Vice-Chancellor, Sir, this is another big area of my most valuable academic contributions in the field of Farming Systems Horticulture.

8.4.1. Varietal Compatibility

In crop associations, there are different forms of interferences which may be complementary or competitive, beneficial or detrimental to component crops, and may manifest as physiological responses. Whenever two or more crops are mixed they interact either or both in competition and facilitation in space and time dimensions. The association works best when the positive effects are stronger than the negative ones. Intercropping can exhibit a real biological advantage over sole cropping mainly due to two dimensions: spatial and temporal complementarities. In spatial complementarity, vegetable and food crops like maize and cowpeas of similar maturity exploit available niche in such a way that the association may yield more than the best monoculture. In temporal complementarity, earlier-maturing vegetable crops exploit an early-season niche in association with slow-growing, late-maturing food crops like cassava, yams, and plantain.

Determination of varietal stand density in mixtures can result from two techniques quantified by de Wit (1960): 'Replacement series' in which all mixtures and monocultures are grown at equal density by replacing a certain proportion of one species with the same proportion of the other species; and 'Addition series' whereby one species is grown in full (sole-crop) density and the associated species is interplanted at varying densities. In our works, both series were adopted in formulating stand density and estimating vegetable performance in mixtures with food crops.

My detailed research studies on varietal complementarity and 'replacement and addition series' centered on 2-species and 3-species associations briefly discussed below:

Vegetables in Mixtures with Cassava

Cassava-based intercropping is a widespread practice in Africa. Cassava is an important staple food for 160-200 million people or 40-50% of the population, mostly in West and Central Africa.

In cassava/okra addition association, pod yield of okra was about 80-90% of sole-crop yield and the mATER ranged from 1.01-1.38, but the yield varied with density and cassava variety. The longer the maturity and the higher the canopy of the cassava variety (cv. Odonbgo), the higher the pod yield of the associated okra and greater the value of mATER (Olasantan & Olowe 2006).

However, in cassava/pepper mixture, pepper fruit yield was depressed by 20-26% the longer the maturity and the taller the canopy of the associated cassava, but the relative yield was similar to that of sole crop in combination with the shorter-canopy, earlier-maturing cassava variety (cv. Idileru or TMS 30572), indicating different depressive effects of the contrasting cassava types. We also found variations in the pattern of fruit production of the associated pepper varieties. Earliness to maturity of Tatase was more apparent than those of Atarado and Sombo due to their late maturity, shade tolerance, and inherent lateness in fruit production (Olasantan, Salau & Onuh 2007). Overall, cassava/Sombo pepper mixture was the most-efficient where the pepper varieties were least affected by the later-maturing, higher canopy cassava variety. In cassava/melon mixture, cassava moderately reduced seed yields of the melon by 15-25% mainly due to 35% reduction in its LAI. Means for LER and mATER were 1.64 and 1.18, respectively.

We established that in cassava/vegetable association, no or a moderate cassava depressing effect on the vegetables mainly due to temporal complementarity. The association had a higher biological efficiency, though growth habits and competitive relationships of the vegetables remained essentially different. A synergism association was evident, vegetables and cassava combined well resulting in greater yields than their individual sole crops. Cassava provided an early season niche which the vegetables occupied and had a reasonable growth and also benefiting itself from the association by an early dry matter distribution and increase in root yield. Cassava showed a high degree of plasticity due to its long growth and recovery ability which to a large extent compensated for the initial little depression from the vegetables.

Vegetables in Mixtures with Yams

Yams (*Dioscorea* spp.) are important tuber crops in West Africa and in other parts of the humid Africa. Nigeria remains by far the principal producer, it accounts for 72-76% of about 25 million tonnes of the total world annual output. Association of yam with pumpkin gave a relative pumpkin apical shoot or seed yield of about 95%, tended to have the same yield with the sole crop, mATER was 1.65-1.71. Pumpkin's economic value depends largely on the size and quality of fruits and apical shoots. Its growth pattern to a large extent reflected specific measurable physiological or morphological traits. Its apical shoot removal led to reduction in leaf mutual shading and competition at higher densities (10,000-15,000 plants ha^{-1}) and was implicated in growth and dry matter partitioning of the associated yam (Olasantan 2007).

In yam/okra association, three yam varieties (Oniyere, Efuru and Iseosi) with varied growth habits were grown with okra (NHAe 47-4). Yam tuber yields were not affected in the association. However, pod yield of the associated okra varied with growth duration and canopy vigour of the yam varieties. The earlier-maturing Oniyere had greater depressive effect on okra pod yield than the later-maturing varieties. Okra yield increased with its stand density, but a stronger correlation occurred in sole crop than in mixtures (Olasantan & Agbogun 2009).

We established that in yam/vegetable addition association, yam had no depressive effect on the vegetables mainly due to temporal complementarity. The association exhibited synergism and yam plasticity. Yams benefited by modified environment enhancement provided by the associated vegetables which caused an early germination and tuber formation. Soil temperature was 25.3 ^{o}C and moisture content was 108 g kg^{-1} in mixture (about 5.4 ^{0}C cooler and 56 g kg^{-1} wetter than in sole crop yam), a condition similar to an optimum temperature range (25-30 ^{o}C) required for normal yam growth and tuber formation (Olasantan 1999, 2007).

Vegetables in Mixtures with Maize

Maize is a staple food for over 200 million people or 50% out of the African population, mostly in West and Central Africa. It is among the first set of staple crops often found in mixtures with vegetables, and its combination with cassava+vegetables is apparent. Olasantan (1988) showed a decline of melon biomass, fruit and seed yields (about 40%) in an addition mixture with maize (cv. TZSR (W)). There was a further decline (30-60%) in melon fruit and seed yields due to a sharp reduction (50-65%) in its LAI with growth of the associated maize (cv. TZSR-Y-1) in two years' late seasons (Olasantan & Babalola 2007). Melon's economic value is in seed which was strongly correlated with the number of fruits per plant (r = 0.72*). LER ranged from 1.34 - 1.43 due to high relative maize yield.

In maize/okra addition mixture comparing two contrasting maize varieties, we found that the shorter the growth duration and the less depressive the maize variety, the greater the pod yield of the associated okra (55-88% of sole crop yield), and the greater LER. Conversely, the longer the duration of the maize, the greater depressive effect on the associated okra pod yield (45-75% of sole crop yield). The high variation of okra yields was attributed to differences in competition exerted by the maize varieties independently.

We established that in maize/vegetable mixture, growth and yields of the associated vegetables were always depressed by maize vigour and stand density mainly due to spatial complementarity. However, maize variety with erect leaves (kewesoke) allowed more light to reach the associated vegetables. Variety with a relatively high HI, having less vegetative vigour and competitive effect formed a compatible association with vegetables.

Vegetables in Mixtures with Grain Legumes

Grain legumes (cowpeas, beans, groundnuts and pigeon peas) are important food crops widely grown in tropical Africa. West Africa is the largest world producer. Nigeria accounts for about 55% (4.2 million) of the total world land area under cowpeas cultivation alone. In field trials on cowpeas/okra replacement mixture (Olasantan & Aina (1987), okra produced about 62% of sole-crop yield with LER of 1.28. The high relative yield of the associated okra was due to the absence of competition effects. However, in another replacement association with two different cowpea types and okra (Olasantan 1991) pod yield of the associated okra varied with cowpea varieties. The earlier-maturing, erect cowpea variety reduced pod yield of the associated okra by 50%, while medium-maturing, semi-erect variety further depressed yield by 60%, indicating greater competitive vigour of the medium-maturing cowpea variety. The high variation in relative yields of the associated okra was due mainly to cowpea varietal effects rather than mixture stand density effects.

In a further replacement study on early-maturing, erect cowpea type with determinate and indeterminate tomato varieties (Olasantan 1991), we found out that indeterminate tomato variety apparently performed better than determinate variety. The mixture gave a relative indeterminate tomato yield of 50% compared with determinate tomato yield of 40%. Cowpea grain yield was more depressed in mixture with the associated indeterminate tomato variety. Variation in total yields was attributed to tomato varietal competition vigours.

The conclusion from cowpea/vegetable mixtures is that a vigorous cowpea variety combined with a non-vigour vegetable may considerably depress the yield of the latter. On the other hand, a combination of cowpea variety with lowly competition vigour with vigorous vegetable may affect the yield of the former. The best results would therefore be expected from combinations of vegetable with low overall vigour and a non-vigorous cowpea variety of erect canopy and short duration (60-90 days), both planted at about the same time and stand density.

Vegetables in 3-species Mixtures with Food Crops

In 3-species addition mixtures with vegetable crops, my research studies centered on cassava+ maize, plantain+yam and plantain+cassava associations. In a 3-species addition mixture on okra in combination with one cassava variety (Odongbo) and two contrasting early and late maturing maize varieties (Olasantan 1999b), we found out that okra pod yield was sharply depressed by 53%. The mATER value for the total yield ranged from 0.74-1.11. The high variation in relative pod yields of the associated okra due to maize vigour illustrated the inherent competition effect of maize as a dominant species, and its depressive effect in determining most growth and yield characters of okra. However, the competition effect of maize was relatively less severe in the association with early than late-maturing variety.

The trends of vegetable response in plantain+yam and plantain+cassava associations were similar to those of yam+vegetable and cassava+vegetable mixtures, respectively, discussed earlier. This is due mainly to the fact that plantain is slower-growing, later-maturing than yam and cassava and its competitive effect on the associated vegetables was less than that of yam or cassava. In the 3-species mixtures, synergism was also evident and plantain also showed a high degree of plasticity.

8.4.2. The Effect of Stand Density

In a 4-year replacement study at Ila-Orangun (Olasantan & Aina 1987; Olasantan 1991), using projected okra and tomato density of 35,000, 50,000 and 60,000 plants ha^{-1} in monoculture and 20,000, 26,000 and 45,000 plants ha^{-1} in mixtures with cowpea, we found that population at 50,000-60,000 plants ha^{-1} gave the highest fruit yield in monoculture, but 20,000 tomato plants and 26,000 okra plants ha^{-1} gave a compatible association with cowpea at 30,000 plants ha^{-1}.

Table 11: Mean squares from analysis of variance of vegetative and yield characters of okra at varied populations in the early and late season production trials in south-western Nigeria in 1997-1999

		Vegetative characters			Yield characters			
Sources	df	Plant height (cm)	No. branches /plant	Leaf area (cm^2)	Days to 50% Flowering	No. of pods/ plant	Pod weight (g)	Pod yield (t/ha)
Season	1	588.7**	Ns	222.6**	634.6**	601.2*	33.0**	417.0**
Cropping system	1	62.9**	ns	ns	ns	ns	ns	ns
Population	2	15.1**	6.11*	ns	16.5**	12.7**	ns	34.6**
Season x cropping system	1	ns	ns	29.4**	ns	ns	ns	ns
Season x population	2	ns	ns	ns	ns	ns	ns	6.19*
Cropping system x population	2	ns	ns	ns	ns	ns	ns	ns
Season x cropping system x Population	2	ns	ns	ns	ns	ns	ns	ns

* and ** significant at P< 0.05 and 0.01, respectively. *Source*: Olasantan (2003)

In a 3-year addition study at Abeokuta, using varied okra density in mixture with yam or cassava in the early and late seasons, we found that season, cropping system, plant population, season x cropping system, and season x plant population interactions for some yield variables were significant (Table 11). This shows that okra production is mostly suitable at particular optimum stand densities for specific cropping systems and seasons. Okra population at 35,000 plants/ha in the late season and 50,000 plants/ha in the wet season, gave compatible mixtures with cassava (10,000 plants ha^{-1}). In yam/okra mixture, optimum density of okra at 40,000 plants ha^{-1} and yam (10,000 plants ha^{-1}) gave compatible mixtures. We also found that apical shoot and fruit yields of pumpkin increased with stand density up to 15,000 plants ha^{-1} in sole or mixtures with yams (10,000 plants ha^{-1}) with yield benefits.

8.4.3. Sowing Date/Time of Interplanting

In a series of sowing-date studies conducted at the two agro-ecologies, we adopted a wide range of sowing date strategies and adequately avoided periods of peak competition, disease and pest attacks and bad weather. We recorded successes in tomatoes, okra, pepper, pumpkin and melon. We found that season, cropping system, sowing date, and season x sowing date interactions were significant for some yield variables (Table 12), indicating that vegetable production is mostly suitable at particular optimum sowing dates for specific seasons.

We established that okra pod and melon seed yields decreased sharply by 30-58% with delay in planting 2 or 4 weeks after cassava planting. Melon yield was strongly correlated with soil moisture content (r = 0.89*) and negatively with diurnal soil temperatures (r = -0.95*). Seed yield of melon was further depressed by 40-60% when planted at the same time or 2 weeks after maize. The best seed yield and LER (1.46) in the association were obtained by planting melon 2 weeks before the maize. The highest pumpkin yield and mATER (1.87-1.91) were recorded by planting it at about the same time or 4 weeks after yam. Fruit yield of pumpkin decreased sharply by 38-50% with delays in planting 8 weeks after the yam. The best okra pod yield and mATER were obtained in association by planting okra 2 months after slower-growing, later-maturing Efuru or Iseosi yam variety or by relay-planting it after 5-6 months into a faster-growing, earlier-maturing Oniyere variety.

Table 12: Mean squares from analysis of variance of vegetative and yield characters of okra at varied sowing dates in the early and late season production trials in south-western Nigeria in 1997-1999

		Vegetative characters			Yield characters			
Sources	Df	Plant height (cm)	No. branches /plant	Leaf area (cm^2)	Days to 50% Flowering	No. of pods/ plant	Pod weight (g)	Pod yield (t/ha)
Season	1	584.8**	Ns	Ns	215.7**	18.8*	138.0**	234.4**
Cropping system	1	ns	ns	ns	ns	ns	11.2*	ns
Sowing date	2	9.96**	3.92*	6.70**	6.94**	55.7**	12.3**	83.9**
Season x cropping system	1	ns	ns	ns	ns	ns	ns	ns
Season x sowing date	2	19.2*	ns	7.38**	ns	4.68*	3.94*	3.58*
Cropping system x sowing date	2	ns	ns	ns	ns	ns	ns	ns
Season x cropping system x sowing date	2	ns	ns	ns	ns	ns	ns	ns

* and ** significant at P< 0.05 and 0.01, respectively. *Source*: Olasantan (2003)

We also established that okra sown in the early, long day-length season (April-July) took longer time to complete specific phenological stages, but produced higher fruit yield than those sown in the late, short day-length season (August-November). A close look at Fig. 3 shows that it is not advisable to plant okra in late June-July because of ‘August’ break dry spell or September/October market glut. For maximum yield, the optimal sowing dates target for pumpkin is March-April, pepper is May-early June, and tomato or melon is March-April for early season and August-early September for late season.

8.4.4. Soil Fertility/Nutrient Requirements

Nutrient requirement is another major problem in intercropping studies; it varies with crop species and disposition, soil fertility and nutrients being applied. Fertilizer use in food crop/vegetable association is often based on the requirements in pure stands major food crops. In our studies, high N rates up to 120 kg ha^{-1} stimulated maize vegetative growth, and yields of the associated vegetables were depressed when maize vigour competition exceeded a threshold (i.e. that level at which maize competition effects begin to show and depress growth of associated vegetables). Nitrogen rate needed for the maximum yield of tomato or okra grown with cowpea, maize or cassava is 30-60 kg N ha^{-1}, and the highest complementary rate with grain legumes using **LER** is 30 kg N ha^{-1} (Table 13). Okra became superior to tomato in reducing the competitiveness of the food crops at 60 kg N ha^{-1}. At 90-120 kg N ha^{-1}, maize clearly became far too aggressive, out-competing the vegetables.

Table 13. Relative yields (L, cow=cowpea, tom=tomato, okr=okra), LER of cowpea+tomato and cowpea+okra at different nitrogen rates (calculated using the sole crop yields of associated crops (a) with and (a) without applied N

Nitrogen rate (kg ha^{-1})	With tomato			With okra		
	L_{cow}	L_{tom}	LER	L_{cow}	L_{okr}	LER
(a) 0	0.55	0.47	1.02	0.53	0.48	1.01
30	0.60	0.61	1.21	0.62	0.60	1.22
60	0.35	0.48	0.83	0.42	0.49	0.91
(b) 0	0.55	0.47	1.02	0.53	0.48	1.01
30	0.60	0.55	1.15	0.62	0.51	1.13
60	0.35	0.34	0.69	0.42	0.39	0.81

Source: Olasantan (1991)

Mr. Vice-Chancellor, Sir, lack of technology, prohibitive costs and scarcity are the main obstacles that preclude greater use of inorganic fertilizers in tropical Africa. Farmers pay four times the average world price for fertilizers, making them to have a renewed interest in crop rotation and microbial associations like N-fixation. In our work, **N-smart cropping system** was adopted in which food, forage or woody legumes were planted before or simultaneously with vegetable crops in the same field. The forage legumes were then killed or pruned at appropriate times to avoid too much competition with the principal vegetable crops. The objective is: ‘Putting N-fixation to work for small-scale farmers for sustainable management of land and environment in tropical Africa’.

Compared with maize/vegetable mixture, legume/vegetable association showed a different response pattern to applied N because of the often reported complementarity of legume and non-legume associations. We found that residual effects of applied *Gliricidia* hedgerow prunings and preceding cowpea or pigeon pea grown alone or in mixtures increased soil N, P and K statuses by 22.0–25.8, 4.3–9.6 and 4.3–12.0%, respectively (Olasantan 1998). After the preceding food legumes or applied *Gliricidia* hedgerow prunings the succeeding okra and tomato produced higher fruit yields at 30-60 than 90 kg N ha^{-1} (Table 14). Woody legume/vegetable alley system is a technology which African farmers can use to improve soil fertility and vegetable cultivation.

Table 14: Effect of nitrogen application on fruit yields of okra and tomato after applied hedgerow prunings in *Gliricidia* alleys in 1993 and 1994 at Ila-Orangun, Nigeria

Nitrogen Rate kg/ha	No. of fruits/ Plant		Weight/fruit (g)		Fruit yield (t/ha)	
	1993	1994	1993	1994	1993	1994
Okra						
0	7.3	8.3	16.3	15.7	4.7	4.6
30	10.8	11.3	17.0	16.3	6.7	6.8
60	9.3	12.3	16.0	16.0	5.3	7.3
90	8.3	8.7	16.0	15.7	4.9	8.1
Tomato						
0	9.3	9.7	38.4	37.3	13.3	13.9
30	11.8	13.7	41.9	43.0	18.6	21.8
60	12.7	11.5	41.1	42.3	19.3	17.8
90	10.3	10.3	40.0	41.3	15.3	15.8
LSD (p<0.05)						
Vegetable	0.36	0.95	1.81	1.29	1.36	1.09
N rate	1.23	0.94	1.28	1.05	1.29	0.88
Vegetable x N rate	Ns	*	Ns	*	*	*

ns= Not significant, *Significant at p<0.05. *Source*: Olasantan (2000)

Our findings explain technical reasons why small farmers rank among the lowest fertilizer users in the world, and the tropical world, particularly Africa, is poor in its level of fertilizer use (Olasantan 1994). In 2006 at Abuja, African Fertilizer Summit set a goal of boosting fertilizer use to at least 50 kg/year by 2015. Presently, African farmers still use less than 10 kg/ha yearly (only 1% of world's fertilizer) compared with a global annual average of 90 kg/ha.

The implication of our findings is that technology for successful fertilizer use in pure stands major food crops or in intercropping with vegetables is essentially different. Competition enhancement of the dominant staple crops, especially maize, increased with N-rates, which should not exceed 60 kg N/ha. African farmers should be encouraged to adopt other nutrient sources and sensitized to the right technology for inorganic fertilizers, and fertilizers should be made more available at subsidized prices. Fertilizer is a prerequisite for a rapid increase in crop yields. It is not possible to feed about 1.7 billion people in 2050 in Africa without judicious use of fertilizers.

8.4.5. Planting Geometry

Light interception is implicated in crop mixture, especially with crop species of contrasting canopy heights. There is systematically higher resource use efficiency and biological advantage in mixture under favourable light conditions due to spatial or temporal complementarity. Light is intercepted and utilized more competitively by associated crops in space than time dimension. Arrangement of vegetables in mixture with food crops is very crucial in order to enhance competitiveness and growth of the vegetables.

In both addition and replacement mixtures, maize and cowpeas were grown with melon, tomato or okra in different spaced inter-rows and stand densities, and light transmission was implicated (Olasantan 1993, Olasantan & Lucas 1992). Light (52-78%) was intercepted in the association compared with 39-58% in the sole control plots. Widely spaced food crops' inter-rows in mixture enhanced greater light transmission in space dimension and longer duration of efficient light interception in time dimension, and 15-30% higher fruit yields in intercropped melon, okra and tomato than closely spaced inter-rows. We also found that if wider inter-rows were used in mixture, food crops (e.g. maize) with high canopy heights were less aggressive, while vegetable crops with low-canopy heights were more competitive for light and gave higher relative yield. Wider inter-row arrangement of maize or cowpeas became more imperative in addition than in replacement series association.

The conclusion from our work on the varietal compatibility for intercropping is that:

i/ Vegetable crops can perfectly be intercropped with slow-growing, late-maturing food crops like cassava, yams, cocoyam and plantain giving temporal complementarity and preferably using addition series model and the vegetable crops can earlier be planted or both crops planted at about the same time.

ii/ Maize and grain legume varieties for intercropping with vegetable crops should have low vigour and allow more light to reach the associated vegetables giving spatial complementarity and preferably be planted using replacement series technique.

iii/ Plant breeders would need to know how growth characteristics in mixture relate to growth in sole cropping. This would allow the selection of desirable genotypes without the need for expensive screening under mixed cropping conditions.

vi/ Agronomic practices such as high-density, close inter-rows and high-input N fertilizers which lead to high maize vegetative vigour may result in depression of vegetable yields and low or loss of intercropping biological efficiency.

9.0. CONCLUSION AND RECOMMENDATIONS

Mr. Vice-Chancellor, Sir, within the short period of time, we have been able to establish, as you now agree with me, that horticulture is a big treasure in Africa. Indigenous fruit and vegetable crops are treasure troves for African agriculture, and farmers look to them in their cropping systems for many things besides the food they provide. Undoubtedly, horticulture is still an under exploited treasure in Africa. Its contributions to national development cannot be well compared with the myriads of programmes and the huge amount of money invested on it. Africa must improve on its production volume and quality, and its delivery system must be timely and well sustained to have a favourable benchmarking in the global markets.

Africa has the technologies, elevations and enough land and human resources as potential assets to make her be among the highest exporters and consumers for horticultural products in the world. Presently, many of the world's poorest countries are located in the continent. Study conducted in more than 5,000 rural households in Senegal, Mali, Kenya and Madagascar showed that rural society is still very poor in Africa. The average per capita revenue is less than $2 a day in 12 of the 15 regions and less than $1 in 6 regions. In 2005-2007, the Central Bank of Nigeria, an oil-rich nation, one of the top eight world biggest oil producers, the third largest oil exporter to the US, put Nigeria's per capita income at $2.2–2.8 a day. Since 2005, the income situation in the country must have worsened as a result of self-inflicted political and economic impasses. The highest inflation, financial indiscipline, and corruption rates in the world always reside in Africa; Nigeria is among the top few nations. All these have serious consequences on socio-economic development, not only in agriculture but also in education, transportation, electricity, and health yet 40% of the world's resources are located in Africa with only 10% of the world's population.

African nations need to learn from other nations of the world. Efforts geared towards developing agriculture in Asia, America and Europe usually translate to overall social development in industry, health, education and general economy. Agriculture remains the leading employer of labour and a major sector for African economies. It provides powerful leverage for economic and social development. About 80% of incomes still come from agriculture, and 65-75% of Africans still make their living from its activities. With high birth rates and low death rates, African population is growing rapidly, currently 860 million people, expected to rise to 1.7 billion in 2050, and they need beautiful environment and adequate food, fruits and vegetables for the table. If we bring in the feared impacts of climate change on the environment, competition with bio-energy, water and arable land scarcity and loss of biodiversity, African nations face a very big set of challenges. African nations must put in place structural policies to develop horticulture urgently.

The main cropping method occupying more than 75% of arable land in Africa is inter-cropping. Small-scale farmers are yet to be provided with alternative systems which are more acceptable to them economically and technically, and capable environmentally in sustaining crop production. It is, therefore, illogical for African scientists to deliberately abandon intercropping and embrace sole cropping. We must have a reputation for wanting to get considerable improvement in African agriculture. There is no way we can effectively improve crop production technology without improving the system under which they grow naturally.

Technology for horticulture development in Africa cannot be imported as far as realistic achievement is concerned. It is an evolutionary process through which farmers are empowered to discover resources available locally, and improve horticultural production for national development. Intercropping systems are, indeed, experiencing a renaissance in response to problems with monoculture systems. This should not be seen as going back to ancient peasant ways, but, rather, as adopting useful technological aspects of the practice amenable to precise rules of conventional cropping systems like it is being widely practised in Latin America, China, India and Malaysia. The methods described in our works find their best use in organic farming and fit into modern systems.

Given the ecological and sustainable advantages of intercropping and the environmental and economic problems with monoculture, it seems reasonable to continue research on the possibility of improving intercropping to serve as both buffer and driver to African economy and development. I have the following suggestions and recommendations:

● **Enhancing Capacity Building in Horticultural Industry**

Presently in Africa, there are few professional horticulturists, and the few available ones are entangled in other aspects of agriculture. There is a limited knowledge and scarcity of adequate information on technology for horticultural crop production, especially in the area of floriculture and landscaping, post-harvest handling and storage techniques. More expertise is required in horticulture to bring about structural change in African economy.

● **Providing Adequate Funds for Research Institutes and Universities**

Funding education and agriculture has always been a big problem in Africa. The amount of money allocated to both sectors is very small to enhancing research and adequate support services and skills in production and post-harvest handling techniques of horticultural crops. This is partly because African governments do not acknowledge real potentials of both sectors in human development. Adequate policy and planning must be put in place to provide enough funds for Horticultural/Agricultural Research Institutes, Faculties/Colleges of Agriculture and Universities of Agriculture to improving research and producing new expertise in horticulture urgently.

- **Introducing Improved Indigenous Horticultural Crop Varieties**

Presently, farmers' choices of horticultural crops are, of necessity, limited to selections that have been bred for monoculture systems. This has resulted in varieties with limited yield in intercropping and also valuable traits of indigenous varieties that make them meet the challenges of shifting agro-ecological systems are virtually going into extinction. There is an urgent need to produce types of horticultural crops which are physiologically better adapted to particular cropping systems and locations. In doing this we need to identify the essential attributes of the types presently available in Africa whether some are even better.

- **Reducing Importation of Fruit and Vegetable Products**

Efforts must be made to reduce or stop importation of fruit and vegetable products to Africa, at the same time increase production and domestic agro-processing and their potential exports. Efforts must be made to improve purchasing power of the people. African nations should use statutory power to invest on regular electricity supply and viable road construction and gear up efforts to monitor importation and distribution of horticultural products and high external inputs like fertilizers, pesticides and other agro-chemicals.

- **Increasing Participation of Private Sectors in Horticultural Industry**

When considering future plans that are aimed at evaluating the potential role of horticulture as bedrock of national development in Africa greater attention be given to private sectors and farmers. There is an urgent need for private sectors participation policy for horticulture development in areas of farmers' assistance, capacity building and research, provision of infrastr-ucture, input distribution and marketing of horticultural products.

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