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FRUITS: FOOD FOR THE BIRDS?

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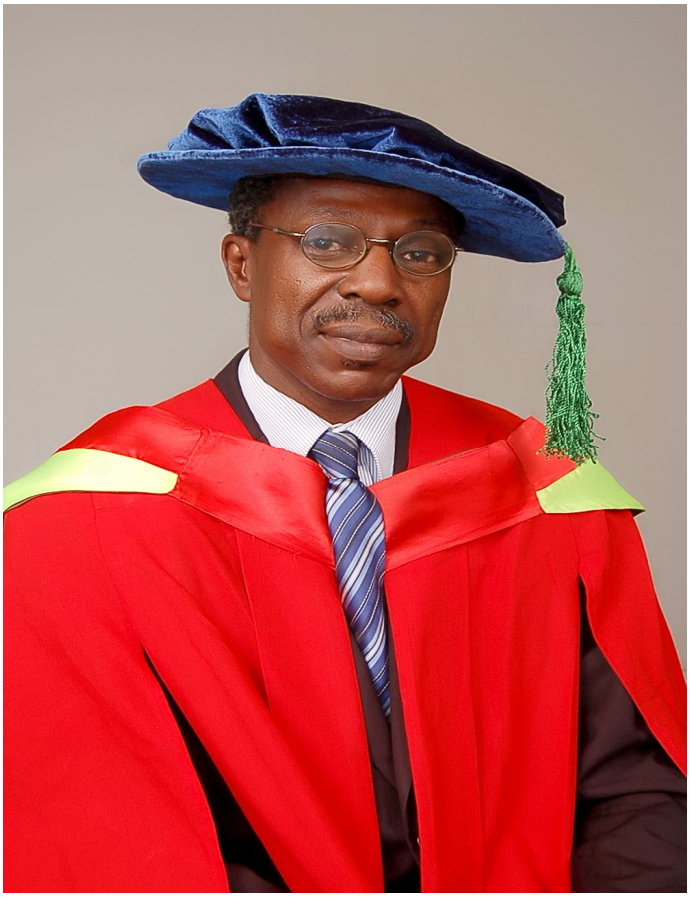

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FRUITS: FOOD FOR THE BIRDS?

The Vice Chancellor, Sir,
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Members of Senate and other Colleagues,
My Lords Spiritual,
My Lords Temporal,
Friends of the University/Special Guests,
Fellow Scholars,
Distinguished Ladies and Gentlemen,
Gentlemen of the Press,
Great FUNAABITES

1.0 INTRODUCTION

A fruit is a fertilized or ripened ovary along with its contents and adhering structures. It is formed after pollination of the stigma by the pollen from anthers. During the process, gibberellins in the pollen trigger off the production of auxin from the developing seed within the ovary which causes the ovary cells to develop and the resulting fruit to enlarge. By this

definition, there are myriads of fruits produced by herbs, shrubs and trees. Some of these are inedible or poisonous e.g. weed fruits, fruits of wild or inedible plants while others are edible.

In his quest for food over the ages, man has purposefully selected some fruits primarily for their taste, other beneficial effects and safety. Thereafter, he articulated degrees of management ranging from mere in situ protection to intensive cultivation in the field of horticulture to sustain their supply. This narrow spectrum of fruits which are edible in their raw form or with minimal processing will be the focus of this discourse. Deliberately, fruit vegetables have been excluded.

It is important to note that the origins of fruits predate mankind whether you subscribe to the Big bang theory of evolution' or like I do, the Creation story. Fruits according to records of the Holy Bible were created before mankind. Interestingly, they are remotely linked to mankind's trouble, because the desire for the attractive yet forbidden fruit in the Garden of Eden and the quest for acquisition of worldly wisdom led to disobedience to God. The sanction for such presumption has been the woes of mankind: a chaotic world to which we are living witnesses. The Holy Bible renders it thus 'Cursed is the ground because of you; through painful toil you will eat of it all the days of your life' (Gen. 3:17 NIV, International

Bible Society, 2006). Before we start pointing an angry finger at Adam and Eve, I believe that there may be men in this audience who as boys, climbed fences without permission, dared the guard dogs and climbed mango or citrus trees right to the top to savour their tantalizing fruits. Of course, some mistakenly broke vehicle windscreens or window panes of houses in their quest for the ripe fruits but managed to escape arrest. Others were not as lucky and got a broken arm in their escape bid ending up with an arm in POP, while the 'luckier' ones got caught and earned a few strokes of the Headmaster's cane on their backsides; not a poor price to pay for a handful of ripe and delicious fruits. That was quite a long time ago, but the question remains; Why is it that some people are fascinated by fruits and acquire the daring of 'Rambo' in their quest for them, while others are cynical about fruits and opine that 'fruits are more or less worthless: they are just food for the birds'. As a Yoruba adage in Ife dialect says '*Ee s'aa f' ogede se, eye lee jee'* ..!'

1.1 The Diversity of Fruits

The diversity of fruits with their assortment of shapes, forms, hues and taste is fascinating (Fig.1). Indeed all things bright and beautiful … the LORD God made them all. Fruits can be classified based on their family, structure, juiciness of the mesocarp and origin. Some important fruit families include the Anacadiacae (cashew, mango), Annonaceae (sour sop, cus-

tard apple), Bromolides (Pineapple), Guttiferae (bitter kola), Leguminosae (tamarind, locust bean), Myrtaceae (guava, wax apple), Musaceae (banana, cooking banana, and plantain), Rutaceae (sweet orange, tangerine) and Sapotaceae (star apple). Based on number of pistils, there are simple fruits formed from flowers with a single pistil. Examples of such include drupes and pomes. There are also aggregate fruits formed from a flower with many pistils and multiple fruits which develop from a cluster of flowers. Multiple fruits develop from individual ovaries from many flowers in a cluster. Based on juiciness at maturity, there are succulent fruits which have juicy mesocarps while others have dry fibrous mesocarps.

Furthermore, based on origin, fruits may be classified into indigenous or exotic fruits. Indigenous fruits are those exploited at the centre of origin/diversity, while exotic fruits are those introduced into another agroecology where they can only be productive under intensive management. In between these to extremes are adapted exotic fruits. These are exotic fruits which over many generations have become naturalized in the new environment into which they were introduced.

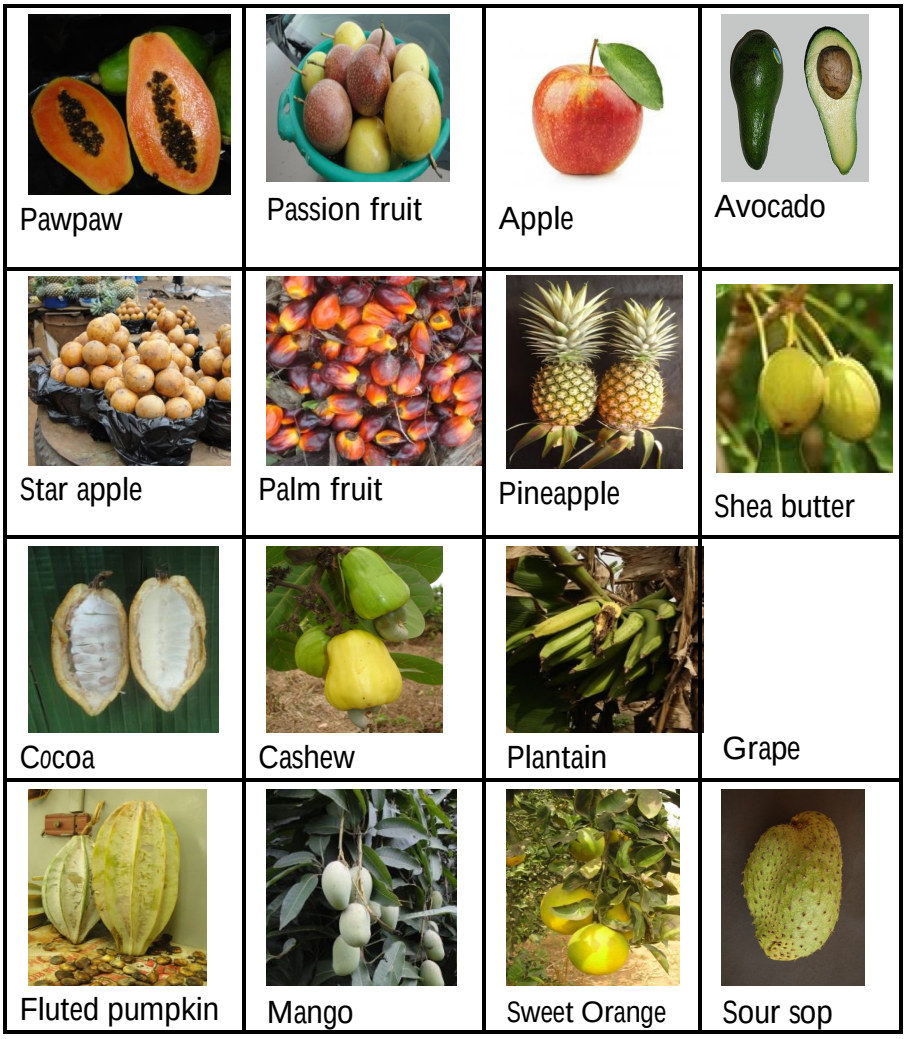

Fig. 1: Diversity of Fruits

Table 1: Types of fruits

Fruit class	Example
Drupe	Mango (*Mangifera indica*),
Berry	Pawpaw (*Carica papaya L.),* Guava (*Psidium guajava L*), Sour sop (*Anona muricata*), Banana (*Musa* AAA) Avocado (*Persea americana*)
Indigenous	Akee apple (*Blighia sapida* Koenig) Tamarind (*Tamarindus indica*) Star apple (*Chysophyllum albidum*), Hog's plum (*Spondias mombin*)
Exotic fruits	Strawberries (*Fragaria vesca sempervirens*), Apple (*Malus domestica*), Grapes (*Vitis vinifera*)
Dry fruit	Baobab (*Adansonia digitata),* Velvet tamarind (*Dalium guineensis*) Locust bean (*Parkia biglobosa*)
Nuts	Cashew (*Anacardium occidentalis*), Cococnut (*Cocos nucifera)*
Folicle	Kola (*Cola nitida*)
Multiple fruits	Grapes (*Vitis vinifera*), Hog's plum (*Spondias mombin)*
Aggregate fruits	Pineapple (*Ananas comosus*)

2.0 IMPORTANCE OF FRUITS

2.1 Food

Food insecurity in Africa remains a painful embarrassment that cannot be wished away. IAC (2004) reported that 200 million people made up of 33 million children go to bed malnourished and hungry every night. Although West Africa fares somewhat better than East Africa with a 60% prevalence of malnutrition, the statistics are not cheering. For instance although Nigeria has a 6-15 % malnutrition rating, in absolute terms this means that with a an estimated population of 170 million people, about 17 million people do not have a balanced meal and are at risk. This figure is more than the combined population of Benin Republic, Togo, Gambia and Sierra Leone!. Given the recent turmoil in different parts of Africa that has turned life upside down on the continent, the statistics are probably direr. Can fruits contribute meaningfully to food security in Africa?

In various recommendations for redressing food insecurity, fruits are hardly ever mentioned; it is likely that most people or agencies that have the mandate to intervene in food insecurity do not think fruits have a significant role to play. The erroneous assumption is often that a belly full of starchy staple will work wonders. The detailed itemisation of starchy staples and the lumping up of all fruits under a single entry in national or regional food security reports supports this line of

thought. However, this assumption is not supported by results of studies in human nutrition: the body certainly needs much more than the high energy carbohydrate foods supply to function optimally. Starchy fruits such as plantain (*Musa* AAB), highland bananas (*Musa* ABB), jackfruit (*Artocarpus heterophylla), A. comunis* and *Treculia africana* have ample potential to meet the energy requirements and at the same time contribute significantly to nutrient requirement of diets.

2.2 Nutrition and Health

Health is the state of well being. Without a healthy populace, all the talk about national development will be like a cloud that brings no rain. Many Nigerian children, less than 5years old, suffer from Vitamin A deficiency (VAD) due to poor nutrition with obvious implications for their eye sight (Ajaiyeoba 2001, Maziya-Dixon *et al*., 2006). Bakare and Olubokun (2011) concluded that the contribution of increase in government expenditure in health care in Nigeria to actual improvement in health conditions is still marginally low.

Non-communicable diseases such as cardiovascular diseases, cancer, obesity and type 2 diabetes mellitus are major causes of death globally (Food and Agriculture Organisation FAO, 2010). They kill their victims slowly. World Health Organisation WHO (2002) reported that low fruit and vegetable intake caused about 31% and 11% of ischemic heart disease and

stroke respectively, worldwide: And that up to 2.7 million lives could be saved if fruit and vegetable intake was adequately increased to the recommended minimum of 400g of fruits and vegetables daily. Moreover, micronutrient deficiencies could be reversed especially in developing countries (WHO, 2003) by adequate consumption of fruits and vegetables. Consequently, Aiyelaagbe (2012) recommended that daily consumption of fruits and vegetables should be embedded in the National Health Policy. For example, besides being a high energy food, banana contains essential minerals such as potassium, calcium, sodium and iron as well as Vitamin A, Vitamin B (thiamine, riboflavin, vitamin B6, niacin) and Vitamin C. (Table 2). The high iron content helps in the production of blood haemoglobin, while the potassium content helps in reducing stress, and is a good natural remedy for diarrhoea. It also helps keep blood pressure under control with its low sodium and high potassium combination. Potassium helps maintain regular heartbeat while its calcium content helps build stronger bones and promotes better sleep.

Table 2: Composition of some fruits per 100g edible portion

	Vit A (IU)	Vit C (mg)	K (mg)	Fe (mg)	Ca (mg)	P (mg)	Mg (mg)	Protein (g)	Carbo Hydrate g
Avocado	-	-	-	0.5	8	34	-	1.5	5.7
Banana	88	5.1	494	0.49	5	18	40	1.08	26.56
Mango	3813	15.1	159	0.16	8	10	12	0.39	18.91
Guava	109	190	292	0.3	15	16	-	0.3	15
Pawpaw	1093	84	183	0.2	30	12	21	0.39	12.2
Pineapple	53	10	98	0.3	18	12	12	0.5	0.5
Yellow Passion fruit	2410	20	-	0.36	3.8	24.6	-	0.18	13.72
Sour sop	0	16.4	320	0.82	9	29	22	0.69	18.23
Sweet orange		39.5	173	0.8	36.7	21.8	11.5	1.13	-
Bush Mango	-	7	-	2	20	40	-	0.9	15.7

Source: Erickson (1968), Wenkam (1990)

As banana contains a large amount of fibres, it relieves constipation as well as creates a great environment for the beneficial bacteria to thrive in the intestines acting as pre-biotics. Furthermore, this fruit helps in tissue regeneration by promoting the retention of calcium, phosphorus and nitrogen. Banana contains no allergen and rarely causes allergies. Plantain (*Musa* AAB) the lesser known relative of banana also has medicinal values apart from its culinary uses. Its use in alternative medicine for curing diabetes and stomach ulcer are documented. Plantain fibre has also been reported to hold much promise for treating Crohn's disease: a condition that causes chronic intestinal inflammation, leading to pain, bleeding and diarrhoea Kirchmann and Kirchmann (1996).

Citrus fruits do not only taste good, they are good for health too (Ecomonos and Clay, 1999). Citrus products are a rich source of vitamins, minerals and dietary fibre that are required for normal growth and development and overall nutritional well-being. Aptekmann, and Cesar (2010) reported that the consumption of 500 mL day^{-1} of orange juice associated with aerobic training in overweight women decreased cardiovascular disease risk by reducing LDL-C levels and increasing HDL-C levels. This association also decreased blood lactate concentration and increased anaerobic threshold, showing some improvements in the physical performance. Similarly, the findings of Li *et al*. (2010) suggest that citrus consumption

is associated with reduced all-cancer incidence.

The pulp, peel, seed, bark, leaf, and flower of mango are rich sources of various polyphenolic compounds with antioxidative capacity property that enables them to protect human cells against damage due to oxidative stress leading to lipid peroxidation, DNA damage, and many degenerative diseases. Some of the important ones include mangiferin, catechins, quercetin, kaempferol, rhamnetin, anthocyanins, gallic and ellagic acids, propyl and methyl gallate, benzoic acid, and protocatechuic acid (Fig. 2). The nutraceutical and pharmaceutical significance of mangiferin has received relatively more attention than other polyphenols due to its potential to combat degenerative diseases like heart diseases and cancer. Of interesting note is the fact that the use of pure isolated compounds has been found to be less effective than the use of crude mixtures from the particular mango part suggesting that synergism of the various mango polyphenols is important for maximum antioxidative activity (Martin and Quian, 2008**).**

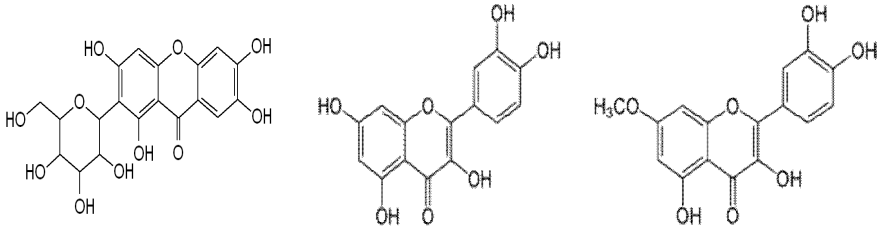

Fig. 2: Structures of Mangiferin, Quercetin and Rhamnetin

Gayosso-García Sancho, *et al*. (2011) identified and quantified phytochemical compounds in pawpaw (*Carica papya* L). These include ferulic acid (277.49 to 186.63 mg 100g $^{-1}$ DW), p-coumaric acid (229.59 to 135.64 mg 100g $^{-1}$ DW), and caffeic acid (175.51 to 112.89 mg 100g $^{-1}$ DW). The following carotenoids, along with vitamin C, increased in the flesh with ripening; lycopene (0.36 to 3.40 mg100g^{-1}DW), β-criptoxanthin (0.28 to 1.06 mg100g^{-1} DW), β-carotene (0.23 to 0.50 mg100g $^{-1}$ DW) and vitamin C (25.07 to 58.59 mg100g $^{-1}$ DW). These results indicate that stage of ripeness significantly influences the contents of bioactive compounds in pawpaw fruit.

Similarly, purple passion fruit (*Passiflora edulis* f. edulis Sims.) has been identified to have constituents which are of medicinal value. The prevalence of wheeze, cough, as well as shortness of breath was reduced significantly in a group

treated with passion fruit peel extract [PFP] (P <0.05), whereas the placebo caused no significant improvement. PFP extract supplementation resulted in a marked increase in forced vital capacity (P < .05) as placebo showed no effect (Watson *et al*. 2008). Pulp and rind extracts of *Passiflora alata* and *Passiflora edulis* act as antioxidants. *P. edulis* rind extracts, rich in isoorientin, have the highest antioxidant activity. Extracts of passion fruits have possible use in control of inflammatory response Zeraik *et al*. (2011).

2.3 Secondary Products of Fruits

Apart from their pleasant taste and nutritional benefits, fruits yield other useful natural products such as essential oils for flavour in the confectionery and pharmaceutical industries, antioxidants and other natural products of medicinal value, enzymes for biochemical processes in manufacturing and dehydrated pulp for fodder, etc, which could be commercially exploited (Table 3). The juice could be fermented into alcoholic and non-alcoholic wines, pulped for nectar, dehydrated fruit pulp for fodder, fruit waste for enzymes such as bromelain, plantain peel for soap, medicines, dyes and spent fruit pulp can be fermented into biogas such as methane which could be used for cooking.

Table 3: Useful products from fruits

Fruitcrop	Useful secondary products and uses
Avocado	Antioxidants, salad dressings
Lemon	Lemon oil for aromatherapy and flavouring
Guava	Pectin,
Passion fruit	Antioxidants (isoorientin), fodder,
Pawpaw	Cericin, capain, papain , pectin, paper, fodder, anti-heminth (leaves), antioxidants-*p*-hydroxybenzoic acid and vanillic acid (seeds)
Pineapple	Bromelain, bran, automotive plastics, biogas, vinegar, alcohol
Plantain	Flour, figs, soft soap, fodder
Bush mango	Weight loss therapy, stearin (for cooking, cosmetics, soaps and detergents), dye, wine, jelly, jam
Shea butter	Cosmetics, Vitamins A and E, cooking oil, leather care, olein
Star apple	Antioxidants

Source: Tella (1979), Wasswa and Olila (2006), Zhou *et al.* (2011)

2.4 Fruits and the Environment

Climate change is a discernible quasi-permanent alteration/ disequilibrium in the quantum and periodicity of the elements of weather e.g. temperature, precipitation, photosynthetically active radiation (PAR) and atmospheric gas content especially Carbondioxide (CO_2). It may be the result of natural or man made activities such as: CO_2 and other greenhouse gas variations, Ocean circulation, volcanic eruptions, solar variations,

orbital variations, land use changes and lifestyle changes. Years ago, many snickered at the alert on global warming and climate change. Not so any longer; the realities are at our door steps! Floods, frost, heat waves, droughts, wild bush fires, mud slides, crop failure, etc, have confirmed that the world does not have enough options to sustain the 'business as usual' attitude to stewardship of the environment. Specifically, World Bank (2012) reported that if not addressed in time, climate change is expected to exacerbate Nigeria's current vulnerability to weather swings, and to limit its ability to achieve and sustain the objectives of vision 20:2020**.**

The pertinent question is: can fruits play a role in mitigating the effects of global warming and climate change? Many tropical fruits are perennials and evergreens. This suggests that they use up significant amounts of CO_2 over a long time. Tropical fruit crops fix between 0.44 and 30 µmol CO_2 m^{-2} s^{-1}, (Fig. 3), storing most of these in the stem and roots. Although these seem small amounts, an extrapolation of the values per seconds into years, and per metre square of leaf area values into total leaf area per plant, multiplied by plant population gives a truer picture of the vast contribution of fruitcrops to carbon sequestration. Their effect is significant whether the fruitcrops are grown on a commercial scale such as in plantations/orchards or included at low populations in diverse agroforestry systems such as multi-storied homegardens such

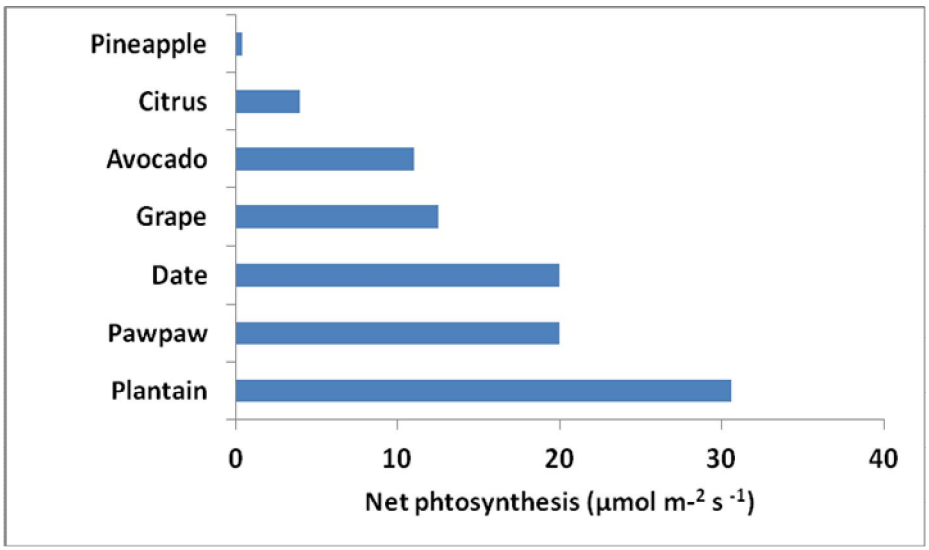

Fig. 3: Net photosynthesis rates of some fruitcrops

Source: Campostini and Glenn (2007), Cayón *et al* (1998) Marler (2011, Raymond and Sakshin (2010), Schaffer (2006)

as occur in some rural parts of south-eastern Nigeria.
Similarly, fruits trees with deep roots such as the mango, make significant contributions to nutrient recycling by lifting nutrients leached to deeper soil profiles through their roots into the leaves and returning some of the nutrients to the soil through litter drop.
Fruit trees also make significant contributions to the hydrological cycle as they form components of shelter belts which

capture, store, and filter water supply as well as protect from erosion, landslides, and flooding.

3.0 FRUIT PRODUCTION AND CONSUMPTION IN NIGERIA

The World Bank-facilitated National Agricultural Research Programme (1994 -1998) gave me an opportunity to see fruit production and consumption in Nigeria in perspective. As I mull on what I saw during the several surveys and my engagement with the fruit industry to date, I opine that not much has changed: fruit production and the productivity of fruit orchards in Nigeria are still low compared with other tropical countries such as Brazil and Thailand. The periods of glut and waste still alternate with the periods of scarcity when fruits are almost 'as costly as the eyeball'; pests and diseases largely have a 'field day 'and the link between fruit growers and processors remains fuzzy. I ask myself reflexively what the matter with fruit production is? What are we doing wrong, or not doing at all? (Note that I use the inclusive noun because as a major contributor to fruit science in Nigeria, I cannot shrug my shoulders or look the other way). Although there is not a shortage of scientific publications on fruit production and handling, the realities on the ground suggest that research doesn't seem to be delivering; or is it? Whereas some African countries are scooping the benefits of a fruit surplus and venturing into export (Table 4), Nigeria hardly gets a mention in spite of its abundant natural endowment for fruit growing which could spin off jobs and commerce. Is it the problem of low adoption of improved technologies

such as varieties, spacing, fertilizer and plant health care because farmers are oblivious of them? Or lethargy due to a low demand for fruits? Arguably, in spite of the growing body of evidence on the benefits of consumption of fruits and vegetables, their consumption is still generally below the recommended levels in both developed and developing countries (IARC, 2003). For instance, Adenegan and Adeoye (2011) reported that undergraduates in Ibadan Nigeria spent only 4.58% of their allowance on fresh fruits.

Much needs to be done to improve fruit consumption in Nigeria; it could result in huge savings in public spending on health care.

Table 4: ACP Exports of Pineapples by African Countries 2008-2010

Country/Year	Quantity (kg)	Value (US $)	Mean Unit value ($/ton)
Ivory Coast - 2008	69,200,511	28,882,194	417.37
Ivory Coast - 2009	54,443,449	21,538,085	395.60
Kenya-2008	224,901	387,921	1,724.85
Kenya-2009	51,635	53,443	1,035.02
South Africa-2008	2,793,522	2,943,681	1,053.75
South Africa -2009	5,076,138	2,966,428	584.39
South Africa- 2010	2,553,829	3,822,881	1,496.92
Tanzania-2008	903,305	95,598	105.83
Tanzania-2009	385,953	65,008	168.44
Tanzania-2010	358,355	95,979	267.83

Source: UNCTAD (2012)

4.0 WHY DO THE BENEFITS OF FRUITS REMAIN UNDEREXPLOITED?

i. Poor / wrong perception of fruits

Fruits are usually perceived as children's food or food for the weak and infirm. Otherwise, fruits are largely considered snacks at best, to be eaten in-between meals because their taste is agreeable. A Yoruba adage probably puts it succinctly '*What's the use of plantains? It's just food for the birds*'. Few farmers consider that fruits are worth investing scarce inputs on. Given this background, it is not surprising that the policy on horticulture is rather fuzzy. Those who make their living in the fruitcrops industry will attest that the challenge of raising productivity of horticultural crops is almost daunting and only a virile policy will switch horticulture to the right track to contribute effectively to healthier and improved livelihoods in Nigeria.

ii Absence of reliable statistics for planning

There is no reliable statistics on tonnage and hectarage of fruit production, imports and consumption in Nigeria. Maybe patchy extrapolations from surveys of limited scope; but generally hardly any results from deliberate nationwide in-depth surveys. If there are no reliable statistics, upon what is planned intervention and budgetary allocation to fund such interventions to be made? How is impact to be measured, how can the next step be appropriately discerned?

iii. Low investment in horticultural research

There are very few Higher Educational Institutions with Departments of Horticulture. To the best of my knowledge, FUNAAB is the only University in Nigeria with a full-fledge Department of Horticulture. Similarly, in spite of the myriads of horticultural crops requiring attention, only one research institute - the National Horticultural Institute (NIHORT), is saddled with the national mandate to optimise the potential of horticulture. Although NIHORT was established in 1975 as the Centre of Excellence in horticulture, its impact is yet to be sustainably felt nationwide: periods of highs are interspersed with those of low. Scientists still work with poor research facilities, funding is inadequate to cope with its rather large number of mandate crops. There is high rate of staff turnover which interrupts continuity in research and often necessitates a fresh start, thus stalling progress. The extension arm of horticulture is also weak. Thus, the 'high yields' of fruitcrops obtained from improved varieties or technologies in the research institute and departments of horticulture often end up on the pages of journals but hardly ever make it to the farmers' orchards or consumers' table. The painful memories of revenue loss due to Black sigatoka disease of plantain will remain etched in the hearts of growers who lost fortunes. What has been the impact to the Nationally Coordinated Project on Horticulture?

iv. Inadequate input supply

The input supply sector for fruits is grossly underdeveloped. Whereas the cocoa industry is spoiled for choice of agrochemicals, and whereas commodities like maize and rice manage to get the attention of breeders and agrochemical marketers with regards improved seeds, fertilizers and pesticides, fruits and vegetable hardly have any. Growers often have to cope with shortage of improved seeds, seedlings or budded seedlings and the vendors are often at the mercy of the elements of weather. Horticultural farmers make a bad job of trying to adapt agrochemicals produced for other commodities to fruit and vegetable production. Consequently, yield and produce quality are often sub-optimal, issues of food safety are often trivialised and the farmers hardly ever profit from fruit growing.

v. High post harvest losses

Due to their high water content, fruits and vegetables are highly perishable and very vulnerable to rough handling. The nutrient content of fresh fruits is often related to their wholesomeness. The sight of black bruised bananas, travelling to the market in the open back of trucks, bruised pawpaw fruits being emptied from local baskets and piles of oranges on the floor is a familiar one in the market place. Why haven't the improved ventilated stackable plastic crates designed for fruits or other improved fruit and vegetable Post harvest handling been

adopted by vendors? What happened to the numerous controlled atmosphere facilities built all over Nigeria in the late '70s?

5.0 MY CONTRIBUTIONS TO THE DEVELOPMENT OF THE FRUIT INDUSTRY

I am sure you did not come here to listen to a swan song. You have probably heard most of what I said earlier in one forum or the other. But I have not just been busy cataloguing the problems; I have tried to be part of the solution. I have had the privilege to give all my adult life in the service of horticulture. My engagement spans three challenging, yet exciting decades during which I have been involved in research, teaching, extension and administration of horticulture. My focus has been on fruit science (Pomology). I trained under the late Prof. M.O.A. Fawusi, (UI/UNAAB), Prof. J.C. Obiefuna (NIHORT) and Dr. B.A. Adelaja (NIHORT). I hope that when my work is done, and it is time to quit centre stage, I shall have helped to make the world a better place by putting more and better fruits on the table at an affordable price all the year round.

5.1 Water Stress

We usually brag that Nigeria is blessed; and that is right. And that any where you drop a seed, you can walk away and come back for the harvest…that is almost true; wishful thinking or

honestly, a hyperbole. Without good crop husbandry, a good harvest remains an illusion..! Fruit crops (i.e fruit bearing herbs, shrubs, vines and trees) left to the mercy of drought are a common sight. Does it make sense to irrigate fruitcrops during the dry season? Most people can understand the rationale for irrigating short season crops like cereals and vegetable crops but doubt the wisdom of extending this practice to perennials like fruitcrops, believing that they can fend for themselves. The truth is that every phase of a fruit crop is moisture sensitive, although the degree of moisture sensitivity differs. For convenience, the various stages of fruit crop growth will be grouped into nursery, post-nursery juvenile phase and the maturity (fruit bearing) phase.

Using pawpaw (*Carica papaya* L) and guava (*Psidium guajava* L) as test crops, Aiyelaagbe and Fawusi (1998) and Aiyelaagbe (1988) showed that drought (soil moisture stress) caused by withholding water from fruit seeds in the pre-nursery influenced seed germination and subsequently the numbers of saleable seedlings available to the nurseryman. Nonetheless, the exact response was species dependent. Whereas withholding water for 6 or 9 days before watering delayed and decreased germination of 'Homestead Selection' pawpaw (*Carica papaya* L) seeds compared with those watered daily, it enhanced the germination of 'Allahabad safeda' guava (*Psidium gujava* L) seeds (Fig. 4). It shows that soil moisture levels that

are adequate for the germination of some fruit species may be excessive for seeds of other fruits species. This questions the rationale of watering by rote adopted by many fruit nursery owners; i.e the 'one size fits all' syndrome. In a world that is gradually waking up to the reality of the fact that the availability of natural resources such as water cannot be taken for granted, wasting of water is not a climate-smart practice and needs to be corrected by training and demonstration.

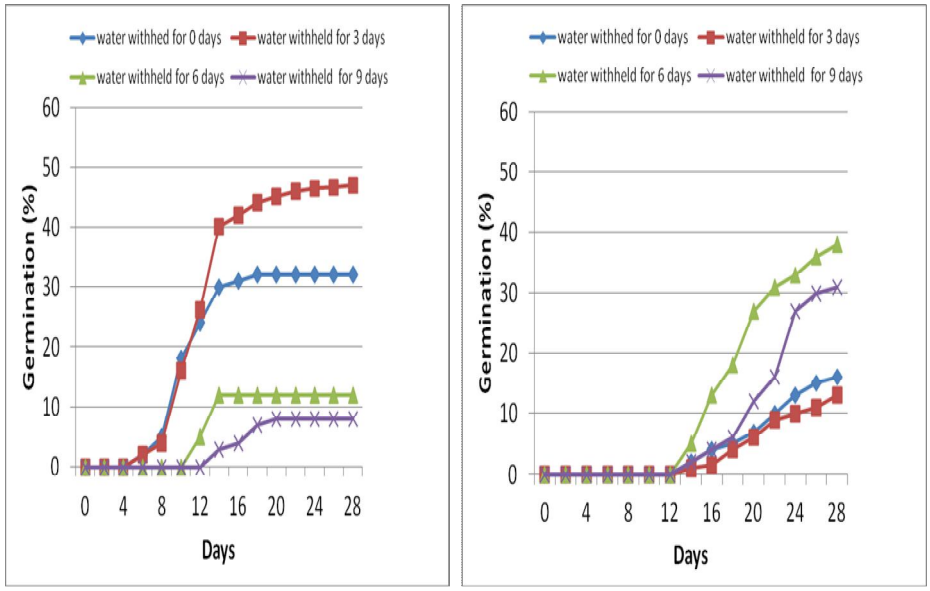

Fig. 4: Effects of watering regime on germination of pawpaw (left) and guava (right) seeds in the pre-nursery

Source: Aiyelaagbe and Fawusi (1988), Aiyelaagbe (1998)

Subsequent stages of growth of fruit seedlings are also moisture-sensitive. Allowing soil moisture to deplete cyclically below -0.02Mpa soil water potential by watering once in 11days retarded the growth of 'Homestead' selection pawpaw seedlings in the nursery and delayed attainment of transplantable size (Aiyelaagbe and Fawusi, 1996). Similarly, (Aiyelaagbe, 1999) reported that water stress caused by withholding water for longer than a week from 'MP4' and 'CP' avocado (*Persea americana* L) seedlings significantly curtailed their growth compared with those watered daily. Withholding water for up to two weeks caused seedling die back and altimately 50% seedling mortality. Although yellow passion fruit (*Passiflora edulis* f. flavicarpa) is a hardy plant, Aiyelaagbe *et al*. (2012) found that application of less than 0.4 L water plant^{-1} week^{-1} significantly curtailed net photosynthesis and growth of four month-old seedlings (Fig. 5.)

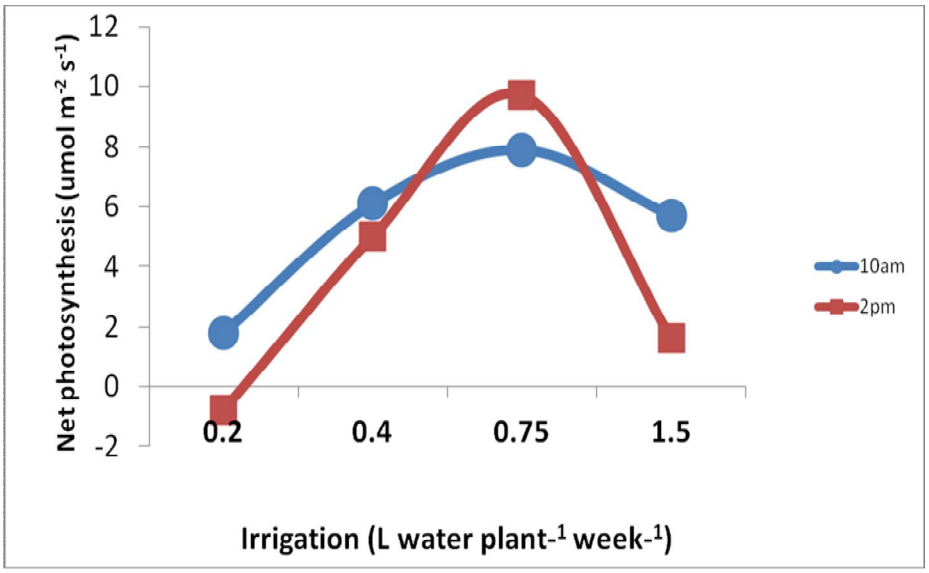

Fig. 5: Net photosynthesis of yellow passion fruit seedlings in response to irrigation

Source: Aiyelaagbe *et al* (2012)

Other experiments showed that fruit crops are sensitive to soil moisture not just at the juvenile stages but at more advanced stages of growth and development. In a greenhouse study conducted at the Institute for Crop Science and Resource Conservation-Horticultural Science, University of Bonn Germany involving rooted cuttings of 'Eureka' lemon (*Citrus limon* L), Aiyelaagbe *et al.* (2005c) found that drought (water stress) significantly decreased the number and surface area

of young and old leaves, as well as the proportion of total dry matter partitioned into leaves. However, it did not significantly influence dry matter accumulation into the stem and roots. Aiyelaagbe and Fawusi (2000) showed that drought imposed by withholding irrigation at the fruit set stage decreased leaf area, total dry accumulation, fruit set and fruit weight of field grown Homestead Selection pawpaw. Furthermore, Aiyelaagbe (1988) found that whereas water stress during the dry season at the mature green fruit stage accelerated the rate of flower drop, premature fruit ripening and fruit drop in Homestead Selection pawpaw, irrigation had the reverse effect (Fig. 6).

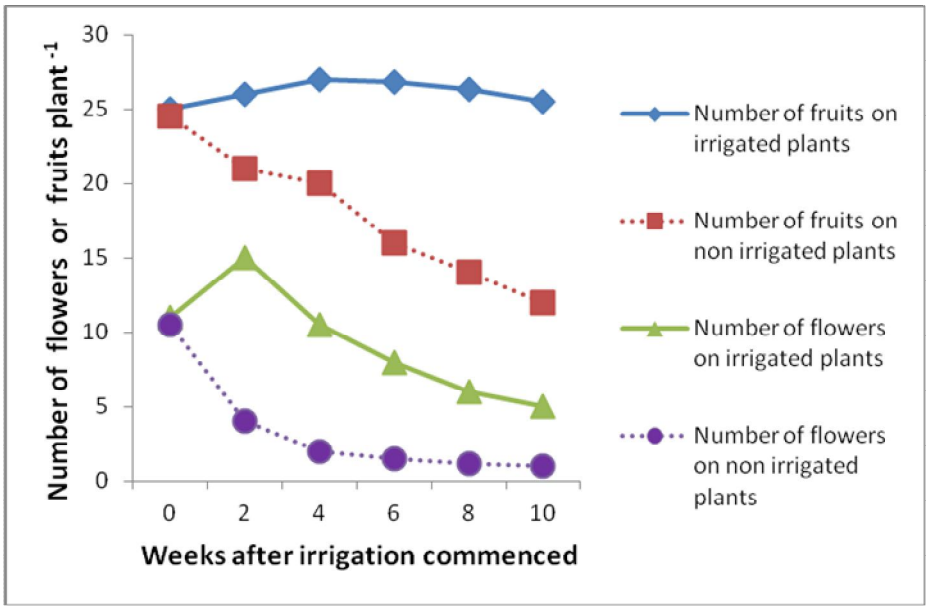

Fig. 6: Flowers and fruit production in pawpaw in response to dry season irrigation

Source: Aiyelaagbe, 1988

How does soil moisture stress exert its deleterious effects? Greenhouse studies conducted by Aiyelaagbe *et al.* (2005d) at the University of Bonn, Germany on two-year old 'Eureka' lemon plants showed that under uncontrolled (ambient) conditions which simulated the orchard, water stress significantly decreased net photosynthesis (***A***), and stomatal conductance (g_s): an indication that CO_2 uptake was reduced due to stomata

closure. It also increased intercellular CO_2 concentration (C_i) an indication that CO_2 previously taken up by plant was not being used up due to limitations in its conversion (Table 5). However, water stress did not significantly influence chlorophyll fluorescence of the plants i.e minimal fluorescence (F_o), maximum fluorescence (F_m), optimum quantum yield (F_v/F_m), effective quantum yield (***Yield***), photochemical quenching (***qP***) and non-photochemical quenching (***NPQ***) thus suggesting that under ambient conditions, the deleterious effects of water stress on leaf gas exchange were due to only the stomatal aspects of photosynthesis (i.e the non-stomatal aspects like photochemistry were not affected).

The effects of water status of plants on photosynthesis can be modified by prevailing light intensity which elicit modifications in the leaves. Under controlled conditions (constant relative humidity, leaf temperature and light intensity) light acclimation of photosynthesis of lemon leaves were modified by water status x light intensity interaction. Water x light interactions significantly influenced ***A*** at irradiance of 50μmol m^{-2} s^{-1} and 300μmol m^{-2} s^{-1} but not at 600 μmol m^{-2} s^{-1} (Fig. 7).

Table 5: Mean effects of water and light on net photosynthesis (*A*), intercellular CO_2 concentration (C_i) and stomatal conductance (g_s) of *Citrus limon* under ambient conditions

Treatment	A (μmol CO2 m-2 s-1)	Ci (ppm)	Gs (mmol m-2 s–1)
Sufficient water	2.13	260.5	41.04
Water stress	0.39	279.0	8.33
Full light	1.67	256.0	27.07
Shade	0.86	283.5	22.31
LSD (p<0.05) water	0.32	21.3	4.66
LSD (p<0.05) light	0.32	21.3	Ns

Source: Aiyelaagbe *et al* (2005d)

At 50μmol m^{-2} s^{-1}, sufficiently watered plants grown in shade had the highest ***A***. Their ***A*** did not differ significantly from that of sufficiently watered plants grown in full light (control), but it was significantly higher than those of water stressed plants grown in shade or full light.

Water stressed plants grown in full light had significantly lower ***A*** than plants subjected to the other water x light combinations. ***A*** of control plants did not differ significantly from that of water stressed plants grown in shade, but they both had significantly larger ***A*** than water stressed plants grown in full light. At 600μmol m^{-2} s^{-1} the water x light interactions did not significantly influence ***A*** (Fig.7).

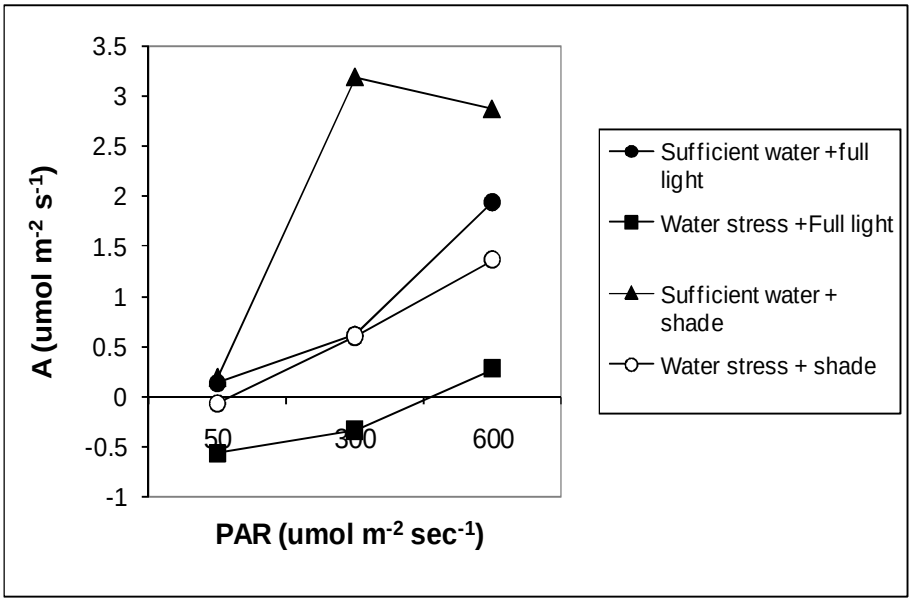

Fig. 7: Effects of water x light intensity combination on light acclimation of photosynthesis of 'Eureka' lemon

Source: Aiyelaagbe *et al* (2005d)

The deleterious effects of water stress on net photosynthesis of citrus were confirmed by Aiyelaagbe and Orodele (2007) in field studies conducted in FUNAAB, Abeokuta, Nigeria. In it they concluded that dry season irrigation with 7.5L water plant $^{-1}$ week^{-1} was insufficient to alleviate water stress and sustain normal growth of juvenile budded Valencia orange trees budded on Cleopatra mandarin rootstock , 60L water plant^{-1} week^{-1} was excessive as it caused water logging, while 30 L water plant^{-1} week^{-1} was adequate as it optimised leaf area development and transpiration.

5.2 Salt Stress

My collaboration with Prof. Dr. Georg Noga, Director of Institute for Crop Science and Resource Conservation-Horticultural Science, University of Bonn, Germany and co-ordinator of the Ger A Hort (Network of African Humboldtian Horticulturists and German Centres of Excellence in plant science), as well as my Humboldt Fellowship host introduced me to research in salt stress. Although salt stress is not prominent in the more humid parts of Africa, the demise of some of the extensive irrigation schemes in the semi-arid parts of Nigeria can be traced to salt stress. When there is excessive application of fertilizer it tends to accumulate in the soil. A good irrigation scheme ensures that enough water is supplied to the soil to leach out the excess salt from the root zone, failing which, under condition of high evaporative loss,

the soluble salts rise with capillary action up the soil profile and are deposited on the soil surface or root zone when water evaporates. The accumulation of these deposits overtime interferes with water and nutrient up take of plants, retards their growth, decreases fruit yield and in extreme cases leads to plant mortality.

Working with potted, fruiting calamondin (*Citrus mitis*) plants, I elucidated the short term effects of progressive salt stress on citrus. The aim of this study was to determine whether it was possible to detect symptoms of salt stress before it became visible to the naked eye and thus, initiate remedial action early enough to avert economic loss. Multiple responses were evaluated to determine which best correlates with the damage caused by salt stress.

Salt stress was created by progressively increasing salt concentration in the Hoagland solution with which the plants were irrigated from 0 to 30 and 60 mMol NaCl. Salt concentration of 60 mMol NaCl decreased net photosynthesis (A) and transpiration (E) by 14% and 7% respectively, but its effects on stomatal conductance (g_s), water use efficiency (WUE) and intercellular CO_2 concentration (C_i) were not consistent (Table 6).

Table 6: Leaf gas exchange and Water Use Efficiency of *Citrus mitis* in response to salt stress

Salt concentration (mM NaCl)	A (μmol m^{-2}s^{-1})	E (mmol m^{-2}s^{-1})	gs (μmol m^{-2}s^{-1})	WUE (μmol mmol^{-1})	Ci (ppm)
0	3.22± 1.12	0.81± 0.61	45.5 ± 4.94	3.97	165
30	2.96 ± 1.29	0.82±0.68	47.81 ± 5.68	3.61	183
60	2.77 ± 1.32	0.75±0.74	43.37 ± 6.27	3.69	165

Source: Aiyelaagbe *et al* (2010)

Four weeks after salt stress treatment commenced, salt concentration in nutrient solution had no consistent effect on total chlorophyll content. However, increasing salt concentration progressively decreased Chl *a/b* ratio, but it increased flavanol and anthocyanin content of leaves by 48-58% and 50-75% respectively (Table 7).

Salt concentration increased foliar content of K slightly (by 4%) , but increased Ca and Fe content by 50% and 75% respectively. It decreased Mg but had no effect on Mn and Zn content (Table 8).

Table 7: Phenolics of *Citrus mitis* four weeks after salt stress commenced

Salt concentration (mM NaCl L^{-1})	Total Chl	Chl a/b	Carotenoid (nmol cm^{-2})	Favanols	Anthocyanin
0	17.2±3.85	1.54±0.28	6.13±1.71	0.95±0.01	0.04±0.0
30	19.3±1.99	1.41±0.16	6.87±0.00	1.41±0.00	0.06±0.0
60	17.4±1.70	1.21±0.07	5.84±0.00	1.76±0.00	0.07±0.0

Source: Aiyelaagbe *et al.* (2010)

Table 8: Foliar mineral content of *Citrus mitis* four weeks after salt stress commenced

Salt concentration (mMNaCl L^{-1})	K	Ca	Mg	Fe	Mn	Zn
	---------- mg g^{-1} DW ----------					
0	13.7± 2.06	17.9± 1.22	4.00± 0.54	0.04± 0.0	0.02± 0.0	0.03±0.0
30	14.1 ± 0.81	16.7± 0.77	3.82± 0.20	0.04± 0.01	0.01± 0.0	0.02±0.0
60	14.3 ± 2.09	26.9± 8.27	3.67± 0.16	0.07± 0.01	0.02± 0.0	0.03±0.0

Source: Aiyelaagbe *et al.* (2010)

Using the Multiplex multi-fluorescence meter (Force A Co. Ltd., France), it was possible to monitor the fluoresce response of the plants to salt stress using a non-invasive method. Fluorescence in response to excitation by far red, red, and ultraviolet light was measured. The measurements were taken weekly to chart the progression. The fluorescence from far red light was relatively more sensitive than others. The time course of Red Fluorescence (RF) was parabolic irrespective of source of excitation. Red fluorescence from red light (RF_R) was largest while red fluorescence from UV light (RF_UV) was least (Fig. 8). During the initial two weeks of the study RF_UV exhibited greater sensitivity to salt stress than RF_R and RF_. With RF_UV, 60mM NaCl induced 47% higher Red fluorescence than control. The effects of control or 30mM NaCl did not differ significantly.

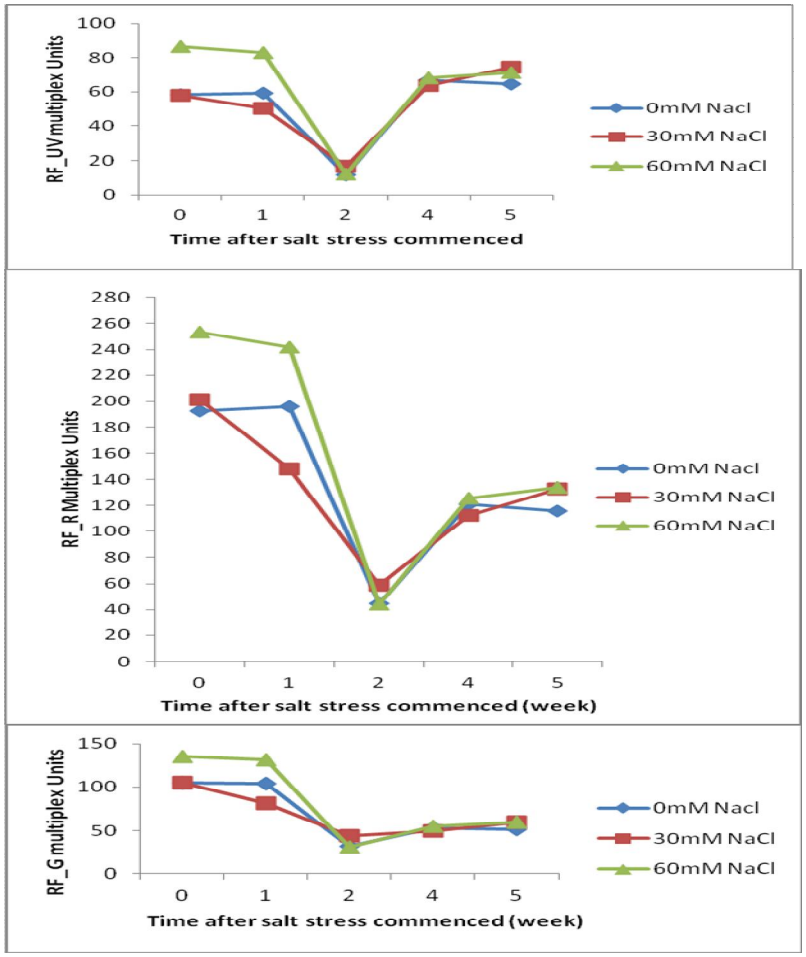

Fig.8: Red fluorescence *Citrus mitis* of leaves with UV, R and G excitation in response to salt stress

Source: Aiyelaagbe *et al.* (2010)

Beyond two weeks after salt stress commenced (2WAS), salt concentration did not influence red fluorescence. RF with UV excitation recovered to previous values of 0 and 1 WAS, but RF did not recover fully with red and green excitation (Fig. 8). Nonetheless, the trends suggest that the citrus leaves adapted their photochemistry to cope with the short term stress.

During the first week of the study, carbohydrate content of citrus leaves was in the order of glucose > fructose>sucrose (Fig. 9). Four weeks later, the glucose and fructose content were almost equal and both were more than sucrose content. During the first week of study, irrigation with 30 mMNaCl nutrient solution increased glucose and sucrose content of leaves but further increase in salt concentration to 60 mM NaCl decreased them.

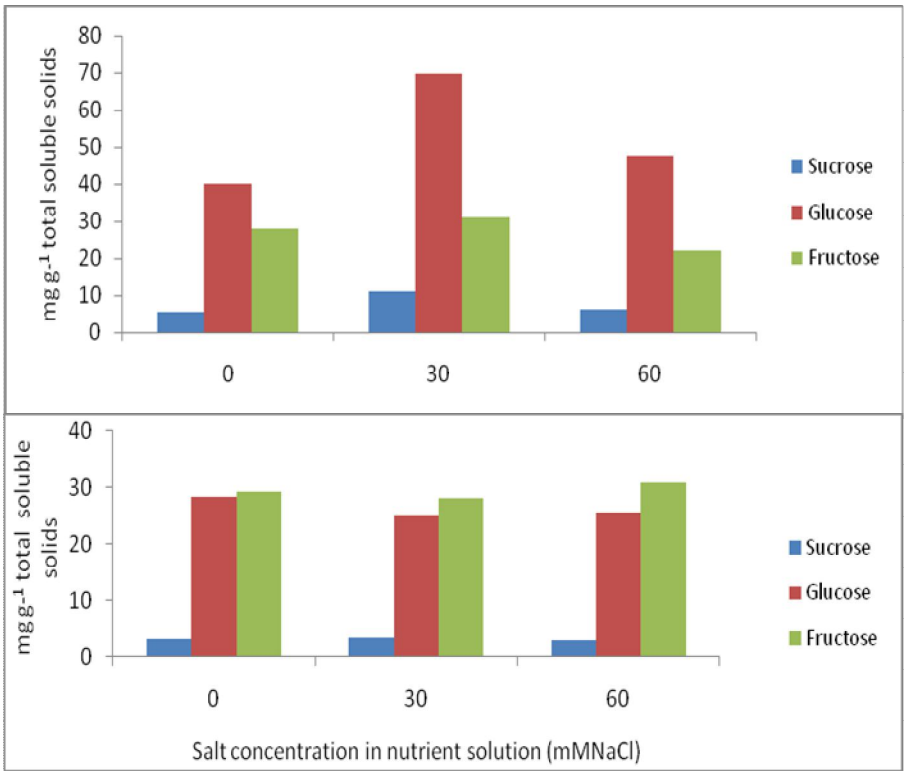

Fig. 9: Effects of salt stress on cabohydrate content of *Citrus mitis* leaves during the first week (top) and fourth week (bottom) of salt stress

Source: Aiyelaagbe *et al.* (2010)

The effects of 30mMNaCl on fructose content did not differ from control but 60 mM NaCl decreased fructose content of leaves. Four weeks later, 30 mM and 60mM NaCl slightly decreased glucose content, increased fructose content but did not differ in their effects on sucrose content compared with control. Which indicates that citrus is able to make osmotic adjustments to avoid damage by short term salt stress.

5.3 Intercropping of fruit trees

I became interested in intercropping studies involving fruit trees mainly out of adventure. Nobody else seem to be doing it; why not? Development of improved technologies for fruit cultivation in Nigeria up to the early 70s presumed on monocropping. Higher yields than on farmers' plots were obtained, and the aesthetics of having well laid out monocropped orchards were lauded during Open Days of research stations. But when it came to extending the results to growers, (most of them small – medium scale farmers), farmers failed to adopt the improved technology package as recommended. Rather they stepped it down to their own system which was based on intercropping: a system in which two or more crops are grown simultaneously or in temporal sequence on the same piece of land (Aiyelaagbe *et al*., 2001). This was no doubt a big embarrassment to scientists who had published nice papers based on years of hard work at tax payers' expense. Yet it was instructive; as the going says, 'The customer

is always right'. This led to a rethinking of the concept of fruit research and gave rise to the fruit crop based farming systems research which embraced intercropping as a veritable production option. The technologies which were produced in this research were useful not only in plantains/orchards but small homegardens/kitchen gardens operated to ensure food and nutritional security at the household level.

Although, intercropped fruit orchards may not look as aesthetic as monocropped orchards, they make economic sense and are based on sound logic on outcomes which include risk aversion, diversification of productions and optimisation of production resources, assurance of a steady stream of income. Aiyelaagbe and Jolaoso (1992) demonstrated that intercropping alleys of pawpaw with amaranths, jews' mallow, *Solanum gilo*, okra, water melon or sweet potato enhanced the productivity of the orchard. Of the lot, intercropping with okra gave the highest productivity. However, sweet potato decreased flower production and fruit yield of the pawpaw (the major crop in the mixture). Thus it was not recommended as a suitable intercrop for pawpaw orchards. The deleterious effects exhibited by the sweet potato intercrop resembled those elicited by water stress; consequently, it was posited that the deleterious effects of intercropping with sweet potato were likely due to competition with pawpaw for soil moisture.

In another study, Aiyelaagbe (2001) found that intercropping with cassava and maize increased the productivity of a young citrus orchard both in biomass and monetary terms, but it decrease the growth and yield of the sweet orange component which was the major crop in the mixture (Fig. 10 and Table 9). This suggests that the benefits of such combination are transient. Conversely, intercropping with chilli pepper and amaranths also increased system productivity without decreasing the fruit yield of the citrus component.

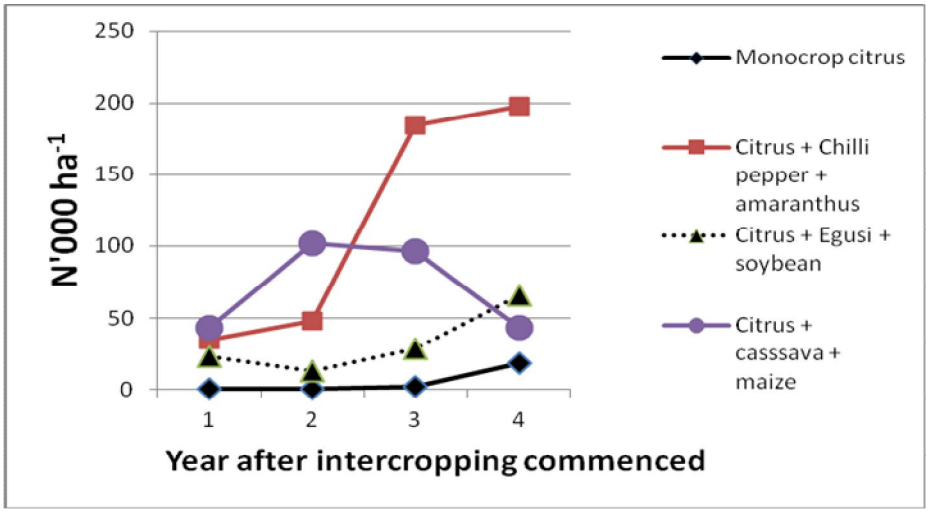

Fig. 10: Revenue generated in an intercropped citrus orchard

Source: Aiyelaagbe (2001)

Conversely, Aiyelaagbe and Jolaoso (1994), Jolaoso *et al.* (1996) and Aiyelaagbe *et al*. (2001) found that plantain (*Musa* AAB) intercropped with soybeans or cocoyam enhanced the productivity of the mixture without deleterious effects on the yield of plantain component. These results show that effect of intercropping fruitcrops depended on the aggresivity of species intercropped. Irrespective of the initial monetary advantage, aggressive intercrops which ultimately decrease the fruit yield from the orchard or plantation should be avoided.

Table 9: Growth and yield of 4-year old intercropped sweet orange trees at Ibadan, Nigeria

Intercrop	Tree height (m)	Canopy volume (m^3 $tree^{-1}$)	Number of fruits $tree^{-1}$	Fruit yield (t ha^{-1})
None (monocrop citrus)	2.80	3.73	57.0	3.08
Chilli pepper +amaranthus	2.90	2.60	58.7	3.92
Egusi melon fb soybeans	2.60	2.23	41.7	2.88
Cassava +maize	2.38	1.20	13.3	0.84
LSD (p=0.05)	ns	1.37	10.9	0.82

Source: Aiyelaagbe (2001)

Fruitcrops are often relatively widely spaced compared with vegetable crops or other crop types. For instance the spacing for pawpaw, plantain, passion fruit, sweet orange and mango are 2.0m x 2.0m, 2.5m x2.5m, 4m x 3m, 7.0m x 7.0m and 10m x 10m, respectively. They also have a slow early canopy growth rate thus large proportions of space in the alleys of juvenile fruit crops are uncovered; posing serious challenges to weed management. Anyone who makes his living in fruit growing can confirm how expensive weed control is. Usoroh (1989) estimated that it accounts for 30% of operational costs. Aiyelaagbe and Kintomo (1999) confirmed weed control benefit of intercropping in their study in a young citrus orchard. They found that growth characteristics of intercrops influenced their weed suppressing ability. Maize and cassava intercrops controlled weeds better than egusi melon followed by soybeans or chilli pepper + amaranths. The enhanced weed control ability of cassava and maize was due to its longer duration of ground coverage compared with other intercrops evaluated, which prevented the weeds from receiving optimum light required for normal growth. The study conducted by Akinyemi *et al*., (2006) showed that intercropping 'Sunrise solo' pawpaw with white pumpkin (*Curcubita maxima*) gave control of spear grass (*Imperata cylindrica*) infestation that was at par with hoe weeding. The net benefit of weed control using white pumpkin that was at par with that of Delsate herbicide.

Olasantan (2007) showed that in addition to the weed control benefits of intercropping with pumpkin, it conserved soil moisture, increased earthworm activity and decreased diurnal maximum soil temperature. Aiyelaagbe and Kintomo (2012) attributed the weed control effects of intercropping to the reduction of light transmission to ground level by interception of solar radiation by canopies of fruit crops and intercrops in the upper and mid-storey of the Plantain-Telfairia mixtures respectively, which decreased light transmission to the ground level.

When sweet orange is intercropped with maize and cassava as farmers often do in south western Nigeria Aiyelaagbe *et al.* (2001), there is initial high revenue from the orchard based on yield of intercrops and savings made on weed control. But it is often at the expense of citrus component, since fruiting is delayed and fruit yield decreased. Nonetheless, by intercropping with less aggressive intercrops such as soybeans, egusi melon, amaranths and pepper, the farmer is able to achieve the benefits of product diversification, weed control, resource utilization and steady stream on income without jeopardising the yield of the citrus component. This phenomenon was confirmed in intercropping studies with pawpaw undertaken by Aiyelaagbe and Jolaoso (1992). They found that sweet potato effectively controlled weeds in papaya plots but was so aggressive that it decreased the yield of pawpaw. In other studies

with plantain, Aiyelaagbe and Jolaoso (1994) and Aiyelaagbe *et al*. (2001) demonstrated that the phenomenon of aggressivity of intercrops was not just species but also population dependent. Furthermore, the results reported by Olubode *et al*. (2012) indicated that apart from intercrop species and their population in the mixture, the timing of their introduction into the alleys of fruitcrops should be such that the period of high resource demand of both does not coincide. Intercropping also affects the spectra of weeds in the intercrop. Aiyelaagbe and Kintomo (1999) reported that intercropping citrus with pepper and amaranthus led to a preponderance of *Tridax procumbens* while intercropping with cassava and maize suppressed it (Fig. 11).

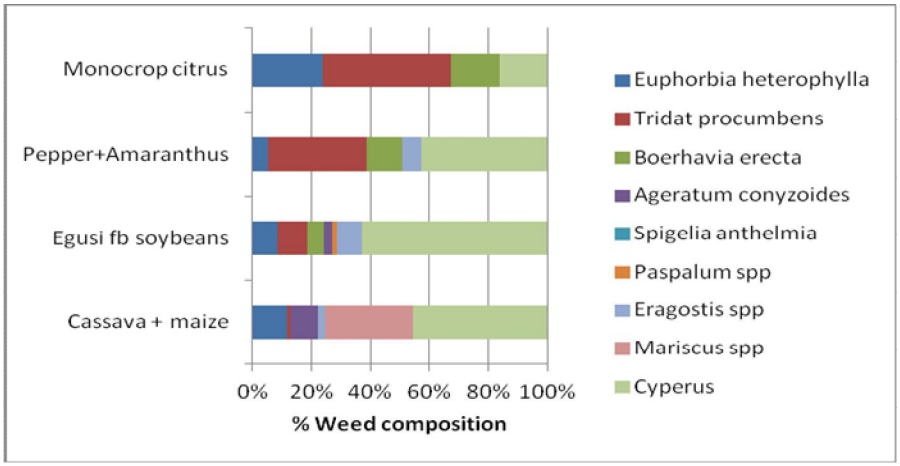

Fig. 11: Composition of weeds (%) in a sweet orange orchard four months after the introduction of intercrops Source: Aiyelaagbe and Kintomo (1999

5.4 Fertilizers: To use or not to use?

Literature is replete with response of fruits to fertilizer especially in temperate zones. As at 1982, when I engaged in fruit science there was paucity of information on fertilizer recommendations for fruit trees especially in the semi arid parts of Nigeria. I wanted to verify if the lack of fertilizer use was based on facts of lack of response or other reasons. Consequently, the response of bearing 'Allahabad safeda' guava (*Psidium gujava*) trees in a high density (3m x 3m) orchard was evaluated on the NIHORT research plots at the Hadejia Ja'mare Irrigation scheme at Kadawa, Kano State. There was no significant difference on the effects of 0.5 – 2.0 kg/tree NPK 15:15:15 on growth and yield of guava. However, a yield response trend was established. Fruit yield peaked at 1 kg NPK 15-15-15 tree-^{1} (Aiyelaagbe, 1989) and I wondered if the yield increase was worth the cost of fertilizer. Next, I ventured into investigating the response of fruitcrops to fertilizers when intercropped. I found that 'Agbagba' plantain (*Musa* AAB) intercropped with amaranthus and telfairia did not respond to NPK fertilization. However, application of NPK fertilizer tended to delay fruiting of plantain (Aiyelaagbe *et al.,* 1996). Understandably so, because the fertilizer used was NPK (20-10-10) which was actually produced for cereals, but that was the brand available in the fertilizer dump. Similarly, 'Paranta' banana (*Musa* AAA) intercropped with telfairia did not respond to 80 – 320 kg N/ha application at Ibadan,

whereas the companion crop telfairia did (Aiyelaagbe and Kintomo, 2002). With the benefit of hindsight 17 years later, I should have done without the fertilizer rather than use the inappropriate brand; time permitting I shall elaborate on this in a subsequent section. Perhaps, some of us are likely to conclude that it's true after all; that it's not worth fertilizing fruitcrops. I would suggest that you suspend your decision until you have heard more information.

In the preceding section, the virtues of yellow passion fruit were extolled. Thus an attempt was made to develop production technologies that would help introduce this relatively unknown fruit to growers in Nigeria. Fertilizer response was the first aspect handled. Aiyelaagbe *et al* (2005b) found that 240 Kg N ha^{-1} was optimal for the vegetative phase of passion fruit. Aiyelaagbe *et al*. (2005a) found that juvenile yellow passion fruit vines that received 500kg N ha^{-1} sourced from NPK +Mg12-12-17+2 accumulated more dry matter than those that received no fertilizer or up to 20t ha^{-1} organo-mineral fertilizer. Furthermore, Aiyelaagbe and Abiola (2008) found that 4.2 $t{\cdot}ha^{-1}$ NPK + Mg (12-12-17+2) fertilizer doubled fruit yield of yellow passion fruit compared with plants that received 5-20 $t{\cdot}ha^{-1}$ organic fertilizer or no fertilizer**.** However, Abiola and Aiyelaagbe (2012) found that compared with control, application of 20t poultry manure or Sunshine Organic fertilizer (SOF) manufactured by Ondo State Government sig-

nificantly enhanced leaf area development and tendril production of juvenile yellow passion fruit. They concluded that poultry manure and SOF could be used as substitutes depending on availability. Similarly, Aiyelaagbe and Afolabi (2006) found that dry matter accumulation by juvenile 'Valencia late' orange plants grown on a loamy sand at Abeokuta was enhanced by application of Pacesetter organomineral fertilizer (2.58% N, 1.10%P, 0.68%K and 0.18 Mg) applied at the equivalent of 2t ha^{-1}.

5.5 Protected cultivation

Protected cultivation involves growing crops under artificially created optimum conditions. To the best of my knowledge this possibility is grossly underexploited in horticultural crops production in Nigeria as most of our crops come from open cultivation systems with all its operational hazards. I am of the opinion that the benefits of increased insolation during the dry season can be exploited with the use of tropical greenhouses fitted with fertigation systems and coloured shade nets which artificially create lights of various wavelengths in the crop environment are worth exploring. In the temperate regions, temperature and not water is the factor that poses a limitation on crop production. In collaboration with Dr. Michael Blanke and Prof. Dr. Gerog Noga, I undertook studies on forcing sweet cherry (*Prunus avium* L.), cultiars 'Samba', 'Prime Giant' and 'Souvenir' at the Klein Alterndorf Research

Station of the University of Bonn, Germany. We found that by covering sweet cherries with clear plastic early in spring, it was possible to increase ambient temperature and relative humidity by 5^{O}C and 10% respectively. However, Photosynthetically Active Radiation (PAR) decreased by an averaged of 23%. This decrease was compensated for by laying a white reflective mulch on the floor of the greenhouse which bounced back light to the greenhouse roof and thus, to trees growing in it. Compared with control, the net effect of covering with clear plastic was a significant increase in mean number of leaves and leaf area per tree by 57%, and 84% respectively, enhanced photosynthesis and early flowering and fruiting. Thus, compared with control the use of plastic covers enabled the farmers to have a premium price crop on sweet cherries by making the fruits available two weeks earlier than other growers who did not use plastic covers.

5.6 Agroforestry and Conservation of Biodiversity

Until 1990, I did not think much of indigenous fruits. However, the award of a research fellowship by the GTZ tenable at ICRAF (now GIZ and World Agroforestry Centre respectively) changed my view. Now I realise that indigenous fruits make significant contributions wellbeing, as well as household nutritional and financial security. I have to admit that my opinion about indigenous fruits was based on largely ignorance. Interestingly, I believe some in this gathering may still be in

that state and I hope this presentation helps to swing public opinion in favour of developing the potential of indigenous fruits in Nigeria.

My mandate at ICRAF was to gather and evaluate information on the potential of fruitcrops in agroforestry systems; a new focus to a science that had hitherto been skewed to timber/ fuelwood and soil fertility enhancing species. As Senior Visiting Scientist, I got to study and understand the virtues of agroforestry and the role of fruits and speak the 'language of foresters' I interacted with world class scientists such as Drs. Michel Baumer, Peter Cooper, David Ladipo, Emmanuel Tourqebiau and Ir. Rick Thijsesen among others. In addition to desk top surveys, I undertook field surveys in major agroforestry systems of East, Central and West Africa to determine from farmers' perspectives on the role of fruitcrops in their systems. These included the coffee banana systems in the highlands (1500 – 2500 m above sea level) of Burundi, Kenya and Uganda, the cashew coconut system of Kenya and the Coco-Kola and oil palm-cassava systems of Nigeria (< 100m above sea level). The focus was on indigenous under exploited fruitcrops managed by small-medium scale resource poor farmers. In all agroforestry systems studied, farmers indicated that fruitcrops ranked high on their priority. The reason for their preference was the contribution of fruits to households-food security and the revenue derived from sale of the surplus

(Aiyelaagbe, 1992). The fruitcrops were integrated in diverse niches of the farm to minimise their negative effects on other crop components. These niches included, home gardens, external boundaries and foodcrops plots. The fruit preferences varied from one country or system to the other. For instance, in the cashew-coconut systems of Kenya the preference was for adapted exotics such as sweet orange (*Citrus sinensis*) and mango (*Mangifera indica*), (Aiyelaagbe, 1994). Conversely, in Uganda the preference was for avocado, while in Burundi it was tree tomato (*Cyphomandra betacea*) and sweet sop (*Anona squamosa*) (Fig.12).

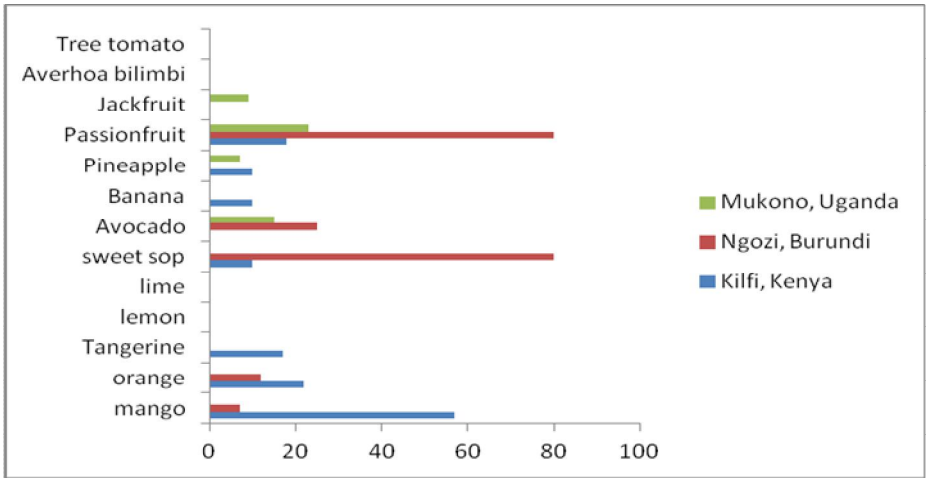

Fig. 12: Fruit preferences among farmers in the coffee –banana and cashew - coconut systems of East and Central Africa

Source: Aiyelaagbe (1992)

Most of the farmers interviewed did not adopt the recommended practices for fruit growing (Table 8). In collaboration with the Humid Lowlands of West Africa Programme (HULWA) of ICRAF, I also participated in identifying top priority indigenous fruit trees for the intensification of the cocoa –kola system and oil-palm cassava system of Nigeria.

Table 8: Adoption of improved management practices by fruit growers in the cashew-coconut system of Kenya

Management practice (% adoption)	Location (% adoption)				System average
	Kilifi (14)	Kaloleni (16)	Mtwapa (5)	Shimba Hills (6)	
Manure of fertilizer	0	16	33	15	16
Budded/ grafted seedlings	5	20	14	28	17
Correct spacing /planting in rows	20	8	47	24	25

Source: Aiyelaagbe (1994).

The idea of focusing on indigenous fruit trees stemmed from the fact that these rustic plant species were often omitted from the agenda of main line horticultural research and were thus at risk of becoming obscure and extinct. Furthermore, these indigenous fruit trees had lower maintenance costs and multipurpose uses such as food, cash, medicines, timber/poles and fuel wood which were very important in rural economies, but less appreciated by specialised cash driven urban communities. The aim of my study was to determine from the farmers' perspective which indigenous fruit trees were most important, why and what use was being made of them. A Rapid Rural Appraisal conducted by Adeola, *et al*., (1994) reported that in the cocoa-cola system of southwestern Nigeria, the most preferred fruit trees were bush mango (*Irvingia gabonensis* and *Irvingia wombulu*). Food and cash benefits were the major motivations for this preference. Conversely, in the oilpalm –cassava system of southeastern Nigeria, bush mango (*Irvingia wombulu)*, bush butter (*Dacroydes edulis),* bitter kola, (*Garcinia kola*) and star apple (*Chrysophyllum albidum*) rated high. Contributions to food security and household income and pharmacopoeic attributes accounted for the high rating. The results of the survey showed that indigenous fruit trees were more exploited in the agroforestry systems of south eastern Nigeria than in the south-western parts. For instance, in spite of relatively small farm holdings, most farmers had 3-6 bush butter

(*Dacroydes edulis*) trees and one bitter kola (*Garcinia kola*) tree on their farms. They earned an average of N1600, N3600, and N4000 per tree of *G. kola, D.edulis and C. albidum* per anuum. Aiyelaagbe *et al*. (1999,1998, 2003). Follow up studies were conducted to determine the character traits that the farmers preferred with a view to include these in breeding / improvement initiatives. Top priority improvement traits identified by growers of *Dacroydes edulis* included shorter trees > sweeter fruits > more fruits > longer fruits >year-round bearing >precocity and increased storability Aiyelaagbe *et al.* (1998). The preferred traits for *G.kola* included decreased bitter taste of seeds, > large seed size >increased tree yields Aiyelaagbe *et al.* (2003).

5.7 Organic Horticulture

Organic agriculture is a knowledge intensive and regulated system of producing and handling food and fibre which exploits the benefits of ecological cycles to achieve sustainability and deliberately excludes the use of agrochemicals which could harm the environment now or later. Although aspects of organic agriculture featured in traditional systems, this was largely by default as there are facts to show that many farmers opted for high input agriculture when afforded the access by many short lived government programmes designed to boost national food security. In short, organic agriculture is a little more than 'what our grandfathers used to do'. There is still

some ignorance and scepticism as well as misconceptions about the workability of organic agriculture (Harris, 2009). Nonetheless, Dipeolu *et al*., (2009) reported that 43% of respondents in a survey agreed that organic vegetable were more wholesome than conventionally grown ones and 33% were prepared to pay 23 – 73% premium on different organic vegetables. Furthermore world trade figures show that business is booming internationally and value of trade in 2009 stood at more than $54.9billion (Willer and Kilcher, 2011).

I helped to start the formal organic agriculture movement in Nigeria. But it was not my original idea. Starting organic agriculture in FUNAAB was mooted by Prof. Georg Steinbach of Gissen University Germany in a challenge thrown over coffee during the meeting of Alexander von Humboldt Alumni of Nigeria in 2003 at the University of Ibadan. The Vice-Chancellor FUNAAB at that time, Prof. I. F. Adu (also a Humboldtian) who attended that meeting bought into the nouvelle idea and supported the formation of a FUNAAB Working Group on Organic Agriculture which focused on research to promote organic agriculture. It was obvious that there was a wide knowledge gap within the working group since most of us had been trained in conventional agriculture. The Alexander von Humboldt Foundation, Germany bridged this by sponsoring a study tour of Centres of Excellence in Germany in 2005 coordinated by Prof. Dr. Steinbach.

Thereafter, the interdisciplinary Working Group gave birth to the Organic Agriculture Project in Tertiary Institutions in Nigeria (OAPTIN). OAPTIN held its first national Conference in FUNAAB in 2005, giving organic agriculture national visibility. Thereafter, these annual conferences have held all over the nation without fail, publishing refereed conference proceedings and contributing to the knowledge bank of improved home grown technologies to help Nigeria exploit the full potential of organic agriculture. This initiative has in turn spawned other organic movements/enterprises such as the Olusegun Obasanjo Centre for Organic Research and Development (OOCORD), Association of Organic Agricultural Practitioners of Nigeria (formerly Nigerian Organic Agriculture Network), Organic Farmers Association which are addressing the advocacy and the business side of organic agriculture.

As some might already be aware, horticulture constitutes a major sector of the international organic trade because health conscious clients consider organic fruits and vegetables more wholesome and with better flavour and thus they command premium prices. I have contributed to learning in organic agriculture in the areas of research, skills gap analysis and capacity building. My studies have spanned fruit vegetables such as cucumber, ornamentals with biocidal/medicinal properties such as marigold (T*agates* spp) and rose periwinkle

(*Catharanthus rosea*) and fruits such as pineapple, pawpaw, plantain and yellow passion fruit. I shall report mostly on the aspect of plant nutrition for organic fruits since others fall outside the scope of this lecture.

One of the most promising fruits crops in Nigeria is the pineapple. After an era of active research on pineapple by Prof. J. C. Obiefuna and the late Mr. Anthony Uncheagwu in 1980s research on pineapple in Nigeria seemed to have 'gone to sleep'. Consequently it was identified as one of the commodities to be promoted by the defunct Research and Development Centre (RESDEC) of this University. My contribution to the development of the Pineapple Project was to articulate a fertilizer recommendation for organic pineapple. Between 2008 and 2010 at FUNAAB, the effects of composted poultry manure applied at 2.5 – 40 t ha^{-1} on the fruit yield of 'Smooth Cayenne' pineapple were investigated at FUNAAB. It was concluded that 5t ha^{-1} was adequate for optimum fruit yield (Aiyelaagbe *et al*., 2012, Fig.13).

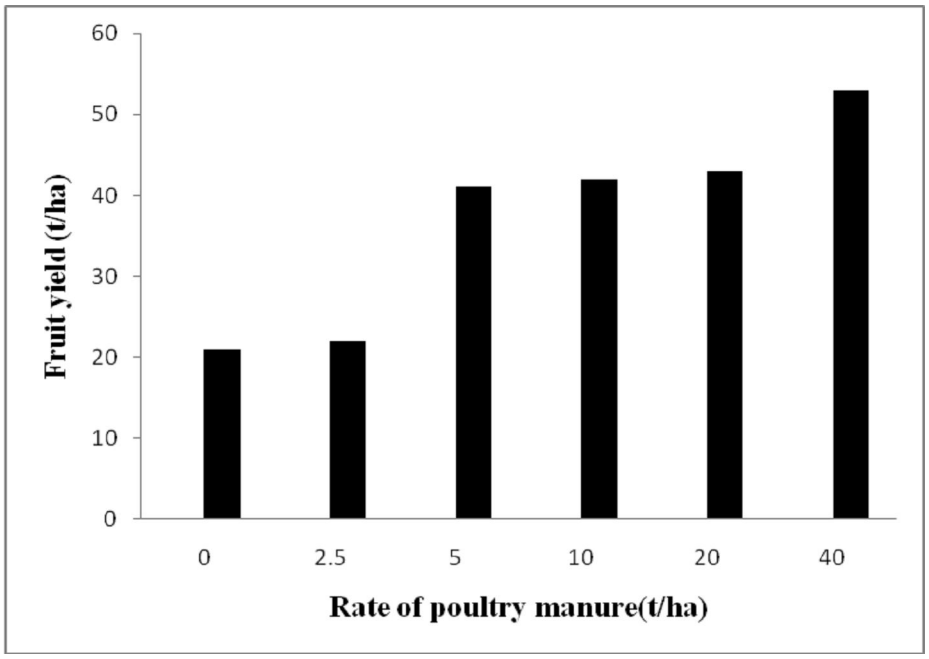

Fig. 13: Poultry manure rates effect on fruit yield of 'Smooth cayenne' pineapple

Source: Aiyelaagbe *et al.* (2012)

As part of the spin-off of a cross-border trade with Benin Republic, a new variety of pineapple 'Sugar loaf' was introduced into Nigeria about 2008. It belongs to the Abacazi group of pineapples, with smaller fruits than the 'Smooth Cayenne'. The fruits are conical shaped fruits averaging 1.4 kg with sweet juicy white to yellow flesh.

Unlike the Smooth cayenne which is selected mainly for processing, 'Sugar loaf' is meant for the fresh fruit market. In the absence of a production technology to extend to prospective growers of organic Sugar loaf 'pineapple, a study was undertaken to investigate its growth response to composted poultry manure at FUNAAB. Aiyelaagbe and Ajayi (2013) found that compared with control, application of composted poultry manure at 2.5t ha^{-1} enhanced the growth of 'Sugar loaf' pineapple slips. Higher rates of application up to 10t ha^{-1} did not significantly increase growth attributes of the slips (Fig .14), thus 2.5t ha^{-1} is considered adequate for the vegetative growth phase.

Fig. 14: Growth response of Sugar loaf pineapple slips to poultry manure rates

Source: Aiyelaagbe and Ajayi (2013)

Plantain (*Musa* AAB) is one of the most profitable fruit crops in Nigeria. It is often under supplied and over priced because unlike its close relative banana, which is grown on industrial scale, in spite of increasing demand for it, plantain has remained largely at the small holder production level due to its exacting demands on soil nutrients. In a study undertaken by Aiyelaagbe and Owoeye (2012) to determine the organic fertilizer requirements of 'Agbagba' plantain (*Musa* AAB), the efficacy of Sunshine Organic Fertilizer manufactured by Ondo State Government and poultry manure were compared. The fertilizer types did not differ significantly in their effects, but optimum growth was obtained at 40t ha^{-1} of either fertilizer, thus suggesting that farmers could continue to use either organic fertilizer depending on availability. However, Phillip *et al.* (2006) studied the effects of poultry manure rates on the productivity of a plantain-telfairia intercrop and reported that found that although 40t poultry manure per hectare enhanced the vegetative growth of plantain and vine length of the telfairia intercrop, compared with control or 20t ha^{-1} of poultry manure, it depressed fruit yield of plantain and did not significantly increase biomass yield of telfairia. Thus, they recommended application of 20t ha^{-1} of poultry manure as the optimum rate of application.

5.8 Capacity building

Capacity building is the impartation of knowledge and skills through a structured method of instruction. In an increasingly competitive world, graduates must possess the right skills to be able to fit into the dynamic labour market and confirm the webometric ranking of their alma mater. The issue of skills gaps in organic agriculture was identified at the inception of the Organic Agriculture Project in Tertiary Institution in Nigeria as one of the constraints to the development of organic agriculture in Nigeria. At the inception of OAPTIN, no Higher Education Institution (HEI) was offering a full-fledged degree programme in organic agriculture. The proposed solution was to equip teachers in agriculture with knowledge and skills required to instruct in organic agriculture at the HEI level. Consequently, in collaboration with Coventry University, UK and with financial assistance of the Department of IUS, UK, under the England–Africa Partnership Project, a National Workshop on Curriculum Development for Organic Agriculture was convened in March 2008. A team of 60 academics drawn from HEIs in Nigeria produced a draft Curriculum for organic agriculture in Tertiary Institutions in Nigeria (UNAAB, 2008) which has been adopted fully or in part by some Universities.

As a follow up to this, an English version for use in the West African sub-region has been published (Aiyelaagbe *et al.*,

2009), while the French version will be published before June 2013. In 2009, the Federal University of Agriculture collaborated with Coventry University, UK using funds supplied by the British Government under the Educational Partnerships in Africa (EAP) and executed the Work Earn and Learn Programme (WELP) which trained agriculture graduates in organic agriculture and encouraged them to set up their own businesses (Aiyelaagbe *et al*., 2009, Aiyelaagbe *et al*., 2010). Thereafter, undergraduates and other interested clients have been trained under the WELP or Summer School scheme. Some of them have started their own businesses or applied the skill gathered in other ways. The lessons learned in this pilot programme suggests that although organic agriculture is hard work, it can be profitable The skills acquisition programme also identified the top four enterprises preferred by the trainees in organic agriculture as vegetable production, marketing of organic produce, poultry production, snail production and fruit production (Fig. 14). These preferences will guide future initiatives in developing the business side of organic agriculture should focus on these aspects. Following up on this, the Skills/Demonstration Plot in Organic Agriculture was established to focus on the further development of the top-priority enterprises listed and to train undergraduates during term time in organic agriculture. To date, more than twenty undergraduates have trained in organic agriculture

horning their entrepreneurial skills and contributing to a steady stream of organic produce available in FUNAAB.

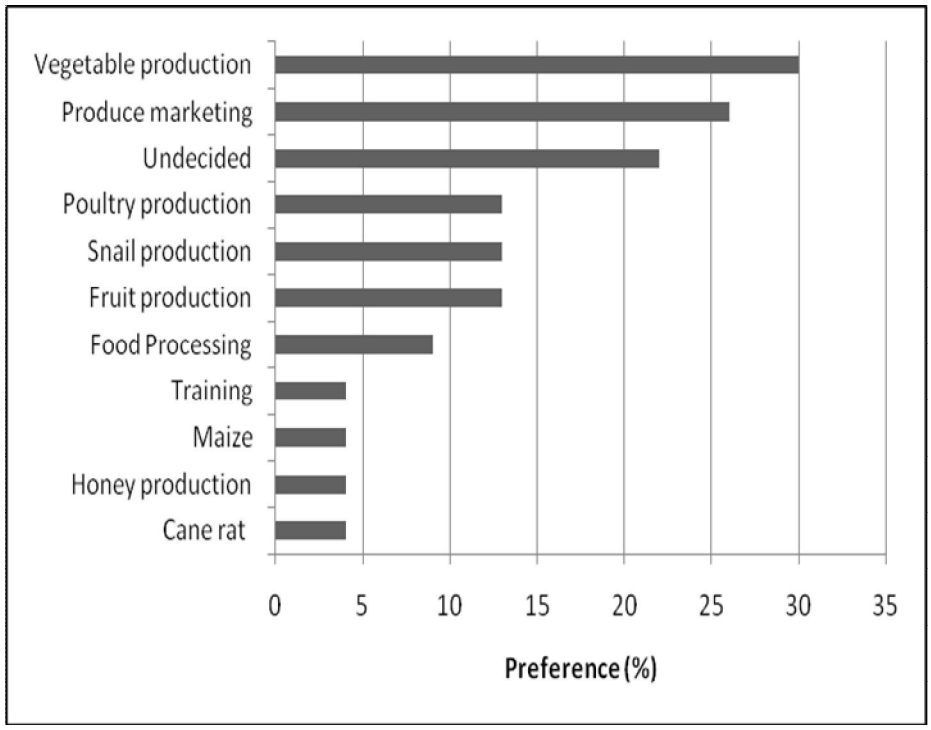

Fig. 14: Preferences for establishment of organic enterprises by WELP trainees

Source: Aiyelaagbe *et al.* (2011)

Since the focus of this discourse is on fruits I shall present only the results on this aspect. Organic fruit production was evaluated using pawpaw cvs. Sunrise Solo and 'Jumbo', pineapple cvs 'Smooth Cayenne 'and 'Sugar loaf', plantain cv. 'Agbagba' and banana. Pineapple and plantain were considered the top commodities to produce due to their low risk and effective demand. A scaled up version of the pilot project has been earmarked for the 2012 cropping season.

The technologies and skills developed from operating organic agriculture in UNAAB have been given wider dissemination in the West African Network on Organic Agriculture Research and Training (WANOART)/ Reseau Ouest Africain pour la Recherche et la Formation en Agriculture Biologique (ROARFAB): An EU facilitated transnational network established by FUNAAB Nigeria and Coventry University UK in collaboration with Université d'Abomey-Calavi Benin Republic, Kwame Nkrumah University of Science and Technology Kumasi Ghana, University of Cape Coast Ghana and Njala University Sierra Leone. In three years of its existence WANOART has trained more than 80 West Africans (mostly from the HEIs) in diverse aspects of organic agriculture and raised awareness and interest in organic agriculture in HEIs in the sub-region.

Similarly, the issue of capacity building to bridge skills gap

identified among graduates of horticulture is being handled through a reconfiguration of the curriculum. It is not a finished job: in the near future, the Department of Horticulture FUNAAB plans to convene a round table with employers of our graduates and invite them to audit our curriculum and make the necessary inputs to produce horticulture graduates with outstanding knowledge of science matched with entrepreneurial skills.

6.0 THE WAY FORWARD

In the forgoing sections, the underexploited potentials of fruitcrops have been highlighted. The next logical question is how can the gap between the current realities and the full potential of fruits in Nigeria be bridged? The following possibilities are worth considering.

i. Advocacy / Health Policy

The National Health Policy as part of its subsection on primary health care lists 'promotion of food supply and proper nutrition'. This needs to be interpreted to include increased consumption of fruits and vegetables to meet the FAO recommendation that not less than 5% of total daily calorie intake should come from non-starchy fruits and vegetables. This can be achieved through advocacy working with the local health authorities at the local government level and in partnership with NGOs. It is most likely that if people are informed

of the afore mentioned benefits of the consumption of fruits from childhood, they are likely to make a life habit of it with mutual benefits for both the growers and the consumers. In addition, the promotion of the consumption of the indigenous fruits hitherto branded 'primitive' or 'poor man's food' by disseminating information on their nutritive values would be helpful. Food vendors should be trained in the wholesome preparation of fresh cut fruits to avoid loss of the vital nutrients and contamination so that all who consume them can get the required benefits. Stakeholders also need to lobby for supply of horticulture friendly inputs that will replace the improvisations and enhance productivity without compromising food safety

ii. Investment in R and D of Horticulture

Fruit scientists are generally in short supply because the relatively long gestation period of fruitcrops delays the receipts of the dividends of investment in training, production or research. Nonetheless, a deliberate effort must be made to train more fruit scientists so that they do not become an 'endangered species'. Furthermore, the government needs to invest more in Research and Development (R and D) of horticulture. Giving consideration to the wide diversity of the fruit crops, funding arrangements for sustained research and development must be long term and adequate. Of utmost importance is the provision of modern equipment to make research

cost effective. Investments in biotechnology as national policy on agriculture highlights should be implemented with vigour. Likewise increased investments in postharvest handling and extension services are pertinent. Of course having made the adequate and timely investments, the government and stakeholders have a right to demand service and should do so. Private-Public Partnerships (PPPs) must be encouraged in such a way that both parties are accountable and benefit mutually. Horticulture Summits need to be convened periodically to enable agencies such as National Horticultural Research Institute, National Stored Products Research Institute, Federal Institute of Industrial Research, Oshodi, Raw Materials Research and Development Council, Federal Ministry of Health, Federal Ministry of Agriculture and Rural Development and organised private sector brain storm on a joint plan to mobilise horticulture for health and improved livelihoods. Extension services in horticulture need to be strengthened by the recruitment of suitably qualified personnel and provision of adequate equipment and transport to be effective.

iii. Fruits in the landscape

The promotion of fruits as part of public and private landscaping initiatives such as home gardens, school gardens, hospitals or public parks and avenues would increase their visibility and availability. The choice of species could be such that guarantees the availability of fruits all-the-year round.

iv. Creation of Standards

Whereas there are standards in the building industry, the pharmaceutical industry etc., there are currently no standards in the horticulture industry. Consumers have been treated with the attitude of 'take it or leave it'. Almost anything can make its way to the market; with a guarantee of ready buyers. This includes damaged, under-sized and under-ripe fruits. Working in consultation with producers, vendors and consumers the Horticultural Society of Nigeria (HORTSON), National Agency for Food and Drug Administration and Control (NAFDAC) and Standard Organisation of Nigeria (NSO) can develop standards such that substandard produce is kept for the compost heap and only good quality produce is sold to the public

v. The Role of the Horticultural Society of Nigeria

Over the last 35years HORTSON has been very active in promoting the science of horticulture. But it's time to shift gears and put an ear to the ground and shift gears. At its inception, HORTSON was designed to be a meeting point for the scientists, growers, government and other stake holders in horticulture. Somehow, the growers and organised private sector have been 'left behind' or is it the other way round?. What went wrong? HORTSON must in the next couple of years work hard to woo them back and offer them a place of honour as veritable partners in progress. Issues of advocacy on increased consumption of fruits and professionalism in fruit growing

and handling must be top the future agenda of HORTSON. It must continue to provide a platform for all stake holders in horticulture to engage in proffering solutions to the various challenges to horticulture in Nigeria. There has hitherto been a skew of research in on-station activities. Now is the time to engage more in on-farm research, on-farm adaptive research and factor in issues of health and climate change into the horticulture agenda. In so doing, horticulture will recruit new and powerful friends in government and industry and remain relevant in the scheme of things.

7.0 CONCLUSION

Mr. Vice-Chancellor, ladies and gentlemen, 'there is so much to read in a kobo worth of news paper that the buyer cannot exhaust it, talk less of the one who borrows it just to glance through'. In the last few minutes, I have tried to painstakingly provide you with a body of evidence in favour of fruitcrops. I must ask again 'Fruits: are they food for the birds, or underexploited sources of health and wealth**?'...** Now that you have the evidence, what is your verdict?

8.0 ACKNOWLEDGEMENTS

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