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QUALITY SEEDS– THE DRIVER OF AGRICULTURAL TRANSFORMATION

By

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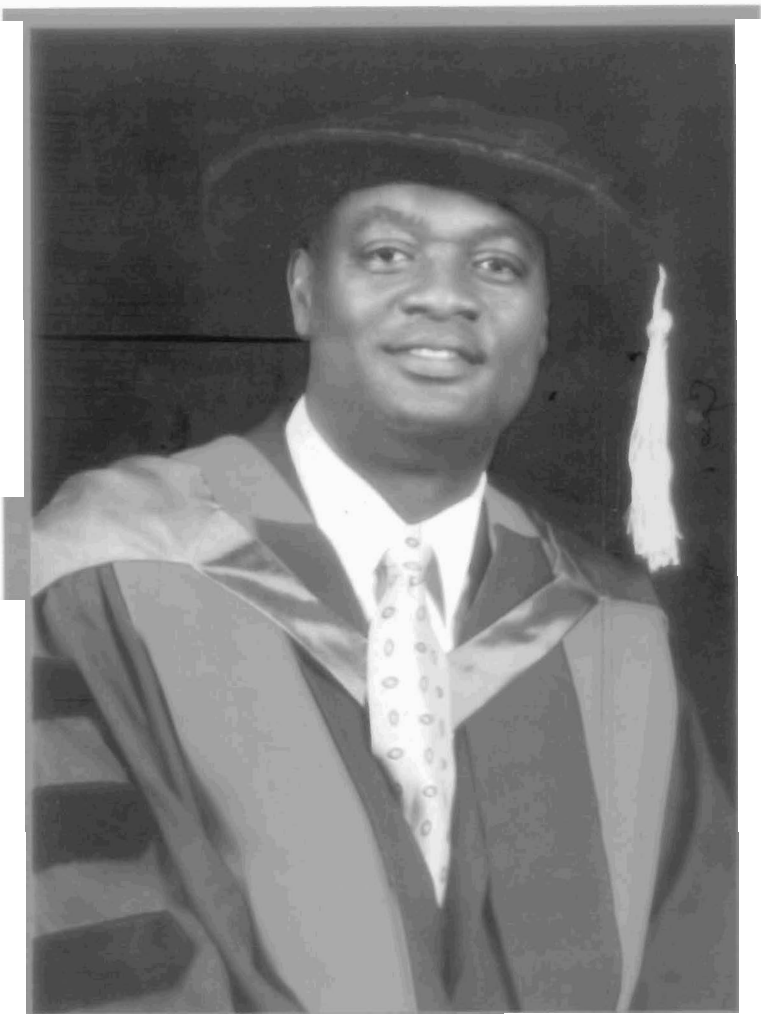

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This was the goal of the leaf and the root, for this is the source of the root and bud. This is the seed, compact of God wherein all mystery is enfolded.

G.S. Galbraith

PRELIMINARY REMARKS

Mr. Vice-Chancellor, Sir, it is with an overwhelming sense of gratitude to the Almighty God, the Father of the Lord Jesus Christ, that I stand before this eminent gathering of University Principal Officers, family members, teachers and mentors, colleagues, staff, students and well-wishers to deliver the 277^{th} in the series of Inaugural Lectures of Obafemi Awolowo University. This is the first inaugural Lecture in the disciplinary area of Seed Science and Technology since this University was established in 1962.

The tradition behind Inaugural Lecture is to give opportunity to newly appointed Professors to present a public lecture relating to their field of study to mark their appointment contrary to the opinion of many people even in the University system that inaugural lecture is to be delivered by very senior Professors. In the words of Professor Igbafe (2013) of the University of Benin, an inaugural lecture is given *to admit a newly appointed Professor formally into office to mark the beginning of his tenure as a leader of knowledge in his specialty and, quite often, in his Department.... it is unthinkable that a Professor would occupy a Chair and retire without giving his inaugural lecture.* In the Conditions of Service for Senior Staff in Obafemi Awolowo University, one of the listed duties of academic staff is *to deliver an inaugural lecture, if a Professor*, and *to endeavour to comply* (that is, deliver the lecture) *within five years of becoming a Professor.* I was promoted to the rank of Professor in 2010 and I am delighted to have been given the opportunity to give the lecture within the tolerance limit of our laws. The path that eventually led me to becoming a Professor in this prestigious University and my specializing in Seed Science and Technology is worth explicating.

It was not by accident that I studied agriculture and became an agricultural scientist and my choice in this regard is deeply rooted in my upbringing in a farming family and community. Quite unusual then and now, I chose Plant Science as my first and second choices and Botany the third when I wrote the University Matriculation Examination. I made the decision to study agriculture while in the third year of my secondary education after I was introduced to genetics. That introduction provided an exciting explanation for a puzzle that no one could explain to me until then. Around late 1970s, a number of families in my village, Igbojaye, were forced by a situation of insufficiency of seeds of the traditional and familiar white maize to supplement with yellow maize seeds and fill the remaining land we had spent days and nights to till manually. This variant of maize had only been newly introduced to farmers in my village and because they had been used to only white maize, few adopted it with caution, considering that it was alien and unimaginable to have yellow pap and the imagination of how it would taste was not only nauseating but also repulsive. But what caught my tender and inquisitive mind was not the colour but the fact that when we harvested the crop, I saw seeds with different shades of yellowness in the ears of the white-seeded type and vice versa despite a few rows of spatial isolation of the yellow- and white-seeded maize fields. I struggled then to know why and how but there was no one around who could provide a logical explanation for my observations. Nevertheless, I held that fascination in my mind for a long time until I was taught what I now know as cross pollination in maize. From that point, reproductive biology in plants became my fascination. Standing here today to present this lecture to mark the inauguration of the first chair in Seed Science and Technology in this University is therefore the capping of what had fascinated my young and inquisitive mind and which, having been held so dear to me, continues to excite me.

The introduction to agricultural genetics in my second year in this University by the duo of Professors T. Olutunla and O. Akinokun reinforced my decision that Agricultural Science was the best for me despite the offer to change to Pharmacy. The opportunity that Dr. Kola Odubote gave to some of us in his genetics tutorial class to be close to him helped in harnessing my inquisition. It was therefore natural for me to opt for my project in plant breeding and genetics under the supervision of Professor M.A.B. Fakorede both at the undergraduate and graduate levels. Barely, six months after the commencement of my M.Phil. degree programme, I was recruited by Professor B.A. Matanmi and offered an appointment as Graduate Assistant in Plant Breeding and Genetics. Later, the Department requested that I specialize either in Plant Breeding and Cytogenetics or in Seed Science and Technology. My farming background tilted my decision in favour of whole plant biology than microscopic examination of chromosomes in relation to crop improvement. My appointment was specifically tied to the take-off of the Seed Science and Technology postgraduate programme which the University Senate had approved in 1988 but which could not be mounted because of lack of specialist. I was not the first to be so recruited for the programme but I was the first to return after overseas training and stay to build a career here as a seed scientist.

I received mentorship from the National Seed Service (now National Agricultural Seeds Council) and the Maize Improvement Program of the International Institute of Tropical Agriculture (IITA). These two institutions afforded me a lot of opportunities for field experience across geopolitical zones in Nigeria. I received postgraduate scholarships from Obafemi Awolowo University, the International Institute of Tropical Agriculture (IITA) and the German Academic Exchange Service (DAAD). I was a University scholar. I was also one of the pioneer recipients of the Dr. S. Aribisala Scholarship for the Best M.Sc. Agricultural Graduate from Nigerian Universities and Agricultural Institutions recommended for a Ph.D.

Programme. The German Academic Exchange Service (DAAD) did not only sponsor my doctoral training in Germany but also provided equipment for the set-up of my laboratory upon return to Nigeria.

Seed Science and Technology is a relatively young science and therefore it is often considered as a minor plant biology discipline and seed scientists are generally in the minority in their respective institutions. Globally, there are very few institutions and individuals that are actively involved in research and training in seed science and technology. Quite unfortunately, the number is decreasing rather than increasing as many seed technology programmes have been scrapped in North American Universities owing to dwindling funding for agriculture (McDonald *et al.*, 1998). Among the remaining few individuals are those who in the real sense are agronomists and plant breeders that extend their agronomic competence combined with traditional understanding and systems of seed technology to make a claim to be seed scientists. Understandably, plant breeders have pioneered the development of the commercial seed industry all over the world because the benefits of the huge human and material investments in plant breeding are accessible to the ultimate beneficiaries only through seeds. Hence, with only a few exceptions, seed science in general and seed technology in particular exists as a sub-unit of plant breeding in many universities. However, Seed Science and Technology is not just about finishing the task of the breeders by processing and packaging seeds in an attractive and eye-appealing form, but is complimentary to other plant biology disciplines. While the world is employing advanced mechanical and biological technologies in producing and testing seeds as well as in detecting GMOs, we in Nigeria are yet to harness the possible limits of the traditional values of the seed of endemic plant species as sources of food, feed and raw materials.

The majority of our native plants used for food and for their curative properties are still collected from the wild with little or no documentation of their reproductive biology. Therefore, they are unknown to science and are also being systematically lost as a result of both the degradation of their natural habitat and over-exploitation. The dearth of basic information on seed production systems, developmental biology and seed characteristics of the species as well as access to a good and reliable supply of high quality seeds are the major factors limiting the production of indigenous vegetables in Nigeria (Adebooye *et al.,* 2005). Consequently, the rich diversity of leaf and fruit vegetable plant species that provides wide dietary variation in a typical traditional African community have been replaced by a narrow range of exotic, often non-adapted, species/varieties. The use of low-quality seed partly explains the low yield of grain crops because farmer-saved seeds, though adaptable, often produce less vigorous and less productive mature plants.

In my review of current trends in seed science and their implications for sub-Saharan Africa (Ajayi, 2007a), I noted that seed technology research and training has received very little attention in sub-Saharan Africa when compared with its significance to the overall development of the region. A comprehensive appraisal of the seed sector in SSA countries was made by the Seed and Plant Genetic Resources Service (AGPS) of the FAO (FAO, 1999). The majority of seed programmes in sub-Saharan Africa, with the exception of some Southern African Development Community (SADC) member countries, have been promoting seed system development independent of research capabilities, extension services, rural infrastructure and farmers' socio-economic conditions and needs. The primary seed research activities in most of SSA involve variety development and testing, release and registration, variety maintenance and breeder seed production, with little or no emphasis on seed biology and technology. Research and training institutions are still not responding to the seed needs of the majority of farmers especially those living under marginal conditions, partly because of lack and/or inadequacy of seed research and training programmes and facilities. The situation is worst in West and Central Africa; only about 10% of the required trained personnel for the Nigerian seed industry is currently available in the country (Omaliko, 1998). The emergence of the West African Seed and Planting Material Network (WASNET) twenty years ago was expected to alleviate this problem. Although commendable success was achieved, the progress was slower than anticipated and by the time the project was completed, the need for a successor programme was apparent. The West Africa Seed Programme (WASP) is currently running and another programme, Alliance for Seed Industry in West Africa (ASIWA) was launched only last week. I had the privilege of serving as a resource person in June 2015 for the Sensitization Workshop to create awareness among stakeholders in Nigeria about ASIWA. The goal of these programmes is to push the use of quality seeds across West Africa from its current level of about 10% to 25%.

To the credit of many retired and some serving academic staff of the Department of Plant Science, now Crop Production and Protection, who have always insisted on clear disciplinary specialization, Obafemi Awolowo University demonstrated foresight with respect to the development of research and training capabilities in Seed Science and Technology by the introduction of an undergraduate course in Seed Production and Certification (CPP 508) around 1981 followed by the conception and approval by the University Senate of a postgraduate programme in Seed Science and Technology as far back as 1988. I was specifically trained and tasked to develop this programme. To give effect to this, the Department through Professors T. Olutunla and M.A.B. Fakorede sought and nominated me for many local and overseas training courses and arranged lectures and hands-on experience for me with the then National Seed Service and the Maize Improvement Program of the International Institute of Tropical Agriculture, both in Ibadan. All these efforts are clear evidence of the recognition that seed science and technology will continue to be relevant and that seed quality will remain the centerpiece of successful agricultural programmes.

Mr. Vice-Chancellor, Sir, I am proud to declare that I have justified the confidence reposed in me at the point of recruitment in 1993 by the successful take-off of the postgraduate programme in Seed Science and Technology in this University and its nurture to an enviable level that has drawn global acclaim and recognition. The donation of basic equipment by the German Academic Exchange Service (DAAD) and the encouragement of all my senior colleagues in the Department were critical motivating factors to take on the challenge. An assessment of seed technology training programmes in Nigeria was undertaken recently by FAO and our programme in OAU was adjudged the best in Nigeria. The programme has been nurtured to such a high level that as Seed Technology programmes are being scrapped in North America, the FAO is currently exploring possibilities for collaboration with a view of designating OAU as a Centre of Excellence for Seed Science and Technology Training for this region. The programme is now oversubscribed and we are unable to admit all applicants. I have graduated 10 Masters and doctoral students beside those I have supervised in other programmes. Currently, 6 doctoral and 4 Masters students are enrolled in the programme out of which 2 have submitted their doctoral and 3 their Masters theses awaiting oral examination. From 2003 to date, I have single-handedly taught four postgraduate courses- CPP 602- Seed Biology; CPP 603- Seed Technology, CPP 607- Seed Storage and CPP 610- Seed Analysis, Testing and Certification.

INTRODUCTION

I have situated this lecture titled ***Quality Seeds- The Driver of AgriculturalTransformation*** in the context of the need for the diversification of the Nigerian economy and the growing courage of the government to revitalize agriculture and make it attractive as a profitable business venture. The development of the agricultural sector is the only way out of the present social and economic quagmires, youth restiveness and unemployment. It is the only unshakeable foundation for the sustenance of the Nigerian economy. There was no dearth of foresight on the danger of overreliance on non-renewable fossil resources and the need for diversification of the Nigerian economy. But the neglect of these warnings and the slow pace at responding to them through appropriate policy interventions have almost stagnated our economy. Whether as a political slogan or as a conscious attitudinal and policy matter, change has been foisted on us by the grim economic realities and the associated social threats starring us in the face today. All of these have forced Nigeria to accept that the diversification of the economy is inevitable and that agriculture, the abandoned first love, is where to begin. Agriculture and civilization have progressed simultaneously along with seed husbandry. The premise of my lecture therefore is that the attention paid to the seed industry will determine both the speed and outcomes of the diversification efforts in general and the agricultural transformation agenda in particular.

It is not just for lack of options that agriculture is being considered first in the long-deferred diversification of the Nigerian economy. Rather, it is because Nigeria is richly endowed with human resources, biodiversity and diverse ecosystems suitable for the cultivation of different crops and rearing of livestock. Nigeria's diverse climate, from the tropical areas of the coast to the arid zone of the north, makes it possible to produce virtually all agricultural products that are grown in the tropical and semitropical areas of the world. Our natural resources and associated potentials are in excess of what is required to make the country food secure and be a net exporter of food and agro-industrial raw materials. The agricultural production potentials, coupled with a large growing population, make Nigeria a potentially good location for agro-based industries and a market for their manufactured food and non-food products. In addition to supplying food and fibre, the agricultural sector is also the major employer of labour in Nigeria because over 70% of the population derives their livelihood directly from agriculture or agriculture-dependent engagements. It contributed 40% to GDP in 2011 and 2012. With the rebasing of the economy in 2014, the contribution of agriculture now stands at 24%. Thus, agriculture is a catalytic trigger for a non-oil dependent economy and only a transformed agricultural sector can generate the required multiplier effect for rapid economic growth in order to afford the majority of our population a decent lifestyle and bequeath wealth to coming generations of our children and grandchildren.

Nigerian agriculture is characterized by considerable regional and crop diversity and the national potential for agricultural production is grossly untapped. Of the 30 million ha arable land, about 33% is under cultivation. The country's share of the global market for cocoa, cowpea, cotton, palm oil and groundnuts has also not been harnessed despite the nation's great potentials. Among leading developing nations like Malaysia, Thailand and Brazil, Nigeria has the lowest agricultural growth. Lack of innovations, inadequate public investment in agriculture and under-developed commodity value chains have been adduced for this low growth. For example, it was reported in the 2012 Agricultural Transformation Agenda Report (ATA, 2012) that average fertilizer use in Nigeria is about 13 kg/ha compared to a world average of 100 kg/ha or 150 kg/ha for Asia. Furthermore, the percentage of farmers with access to high quality seeds in the country is about 5%, compared to 25% for East Africa and 60% for Asia (ATA, 2012). Agricultural mechanization intensity is about 10 tractors/1,000 ha compared to 241/1,000 ha in Indonesia.

Less than 1% of the country's arable land is irrigated, compared to 28% in Thailand. Agricultural transformation is therefore an imperative.

Pivotal to transforming the agricultural sector to drive economic recovery is the supply of quality seeds for crop production because it is whatever a man sows that he shall reap. Indeed, the quality of a man's life is dependent on what he reaps from his labours and toils. For both the crop and livestock sectors of food production, quality seeds are the fulcrum of higher agricultural productivity. All animal products- egg, hamburgers, beef and milk have their energetic origins in plants and the most significant aspect of livestock production is feed and grains make up about 85% of calorific content of livestock feed. One of the fastest ways of accelerating weight gain in livestock animals, especially ruminants, is to feed them grain rather than grass (Barden *et al.*, 1987).

The philosophy behind the topic of this lecture is that an agricultural sector is as strong as the seed sector and that farming is as productive and profitable as the access to and quality of seeds used. High quality seeds produce bumper harvests which in turn increase farmers' income and also make feed available for livestock and raw materials for the industrial sector.

The use of the word 'seed' has a much broader meaning and application in agronomy than in botany. Botanically, a seed is a ripened or mature ovule and a product of sexual fertilization. In agronomy, however, the emphasis is on use rather than origin, in which case the term applies to any plant part or organ that is used to regenerate plant. This then extends the term to cover vegetative parts that are used for regeneration, for example seed yam or cassava stem cuttings. But the discussion of seed quality in this lecture will be limited to the thrust of my research to date that is, botanical seeds as agricultural input for sowing and as germplasm for the conservation of plant genetic resources.

With this background on my journey so far, the state of my discipline and of Nigerian agriculture, the rest of the lecture will follow this outline:

1. Economic importance of botanical seeds
2. Attributes of high quality seeds
3. Production of high quality seeds
4. Influence of seed quality on seedling establishment and crop performance
5. Neglected underutilized species (NUS)
6. Beyond the laboratory: Walking the talk
7. Conclusion and Recommendations
8. Acknowledgements

1. IMPORTANCE OF BOTANICAL SEEDS

The subject of seeds uniquely draws attention and interest. Seeds have been associated with human existence, playing different roles in meeting human needs, sustaining life and providing conveniences associated with it.

Seeds of agricultural crops have been and will continue to be the **major sources of food** worldwide. The substances that are stored in seeds prior to dispersal are in the form of carbohydrates, proteins, fats and oils, minerals and other nutritive biochemical derivatives. These substances are in themselves the basic ingredients that humans need for survival either as direct food, supplements or industrial raw materials for the production of other essentials. According to Egli (1998), dependence on green plants for our food supply is synonymous with dependence on seeds because seeds are used to reproduce crops and are frequently harvested for food and feed. Out of 22 plant and animal food sources listed by Evans (1993), 10 were crops harvested for their mature seeds out of which the topmost three were wheat, rice and maize. Indeed, Heiser (1973) indicated that seeds of these three crops had been the basis of early civilization, suggesting that the importance of seeds as food sources is not a recent phenomenon.

From economic and nutritional viewpoints, grains and pulses are the two most important groups of plants in the world today and they will remain so for the foreseeable future. They account for more than 90% of human food supply. The seeds that sustain life fall into two categories, the endospermic caryopsis of cereals and the non-endospermic true seed of the legumes. According to FAO, of 19 species harvested for their seeds, 15 were from the grasses and pulses family.

Cereals are those members of the grass family *Poaceae* whose seeds are harvested for food or feed (e.g. maize, rice, sorghum, millets, wheat, oat, barley). Similarly, *pulses* are members of the legume family, *Fabaceae,* whose harvested portion is the edible seed (usually a bean or pea- cowpea, pigeon peas, field beans, soya, groundnut, kidney bean, chickpea) (Barden *et al.*, 1987). The grass seed, referred to as the 'staff of life' by Egli (1998), are invaluable sources of dietary carbohydrates, the important metabolic energy component, while the pulses are critical protein sources and have been appropriately referred to as poor man's meat. These seeds have sustained humankind for centuries and the productivity of these crops has increased to keep pace with the expanding world population. Species from only these two groups of plants account for 97% of the total production of major seed crops harvested for food or feed.

Plant seeds are also the main **industrial raw materials** for oil, butter, starch, coffee, chocolate, nuts, to mention only a few commodities.

Botanical seeds are one of the most amazing and fascinating **objects of scientific inquiry** the understanding of which readily finds relevance to human existence and solutions to complex developmental problems. Seeds are biological entities that are living not only because they reproduce the plant life but because they respond to stimuli in discernible and quantifiable measures.

The understanding of the plant's survival and perpetuation strategies in seed production is the basis of the role of **seeds as agricultural input**. In food production, seed is the most important and the starting input, it is the only input that can be reproduced and kept by farmers. While agronomic practices may be performed using conventional or no-tillage principles, with inputs of chemicals and fertilizers or without them using ecological or organic methods, the choice of plant propagule is still limited only to varieties and seed, whether botanical or agronomic, is irreplaceable. Seed is no longer a commodity sold on the basis of weight but a living entity marketed and purchased on the basis of the number of pure, viable and germinable seeds in a lot. Therefore, seed as agricultural input is the embodiment of all production potentials, setting the limit of response to other production factors and agronomic practices. As plant propagule and agricultural input therefore, seeds have been variously described as the *most important product of a plant's life cycle, and... constitutes the evolutionary continuum of the plant species* (Desai, 2004); *necessary input for all agriculture... and the most crucial input that produce entire plant with roots, stems and leaves, and is itself reproducible* (Almenkinders and Louwaars, 1999); *the primordial input, the embodiment of past harvests and the promise of future one* (FAO, 1999); *fascinating, complex biological structures* (Kigel and Galili, 1995) and *mysterious structures containing wonders of life yet to be revealed* (Desai, 2004); *the seed is the first determinant of the future plant development, the master key to success with the cultivation* (Zecchinnelli, 2009).

Seeds are commercial and economic goods. Seeds are now international commodity and many multinational businesses are established and concerned solely with seed (Buanec, 1996). In recent times, major seed companies have forged alliances with chemical companies which have wide investments and expertise in biotechnology (McDonald *et al.*, 1998). The commercial world market for agricultural seed is worth about US$ 50 billion while

Nigeria's domestic seed market accounts for about $150 million (Ajeigbe *et al.*, 2015). Both the commodification of seed and the commercialization of seed production have two direct consequences. Farmers turn to seed companies each year for seed supply, and the trade contributes a significant proportion to local, national and world economies. In areas where seed production companies are established, local people are employed both on contractual, short-term and permanent bases. For example, contract growers are engaged to produce hybrid maize seeds and they, in turn, employ local people when de-tasseling plants. Where post-harvesting operations are done mechanically, local peoples are also guaranteed seasonal employment in sorting out bad ears and kernels during seed processing.

Seeds are now property and instrument of technology transfer. The commercial seed business in the western world has essentially replaced the old practices of seed exchange between farmers. Specifically bred and packaged seeds of many food and horticultural crops are offered for sale to farmers every season. Seeds then have become a channel through which technology can be stored and/or transferred, an interface connecting classical as well as modern plant technology developers and users. Many new advances in the understanding of plant metabolic processes have facilitated manipulations for intended purposes. Biotechnology, therefore, simply "refers to the manipulation of living organisms to alter their characteristics, [to] use them as a component in a larger production process and produce a desired product" (Hoisington *et al.*, 1998). These technologies have brought to the fore the seemingly limitless possibilities to manipulate plants for various purposes. In seeking solutions to many challenging problems farmers and their crops face, modern technologies have been employed in various forms to improve productivity and seed has been the vehicle through which these technologies are transferred to end users. Examples are abundant in the areas of crop adaptation and protection, yield and nutritional improvement, as well as pharmaceutical uses (Larkins *et al.*, 1993; Habben and Larkins, 1995; Krebbers *et al.*, 1997; Richter *et al.*, 1998; The Pew Initiative on Food and Biotechnology, 2001). There is a wide array of possibilities of what could be genetically engineered and passed through the vehicle of seed. For the foreseeable future, seed will play a central role in plant biotechnology.

Botanical seed derives from fusion of both male and female gametes which produce the embryo. Compared with that of the whole seed, the duration of formation and of growth of embryo, is short; a significant portion of duration of seed development is devoted to accumulation of food reserves from the mother plant (Ajayi, 2003). But these reserves do not contribute to subsequent generations other than to nurture the embryo which carries genes of both parents, until such a time that the resultant plant can depend on its own and external resources for continued growth. The two sets of parentally-derived genes and chromosomes are able to interact and recombine to produce new forms that are distinct from those of either of the parents, and occasionally these recombinants are better adapted to the dynamic changes of plants' environments. In this context, **seeds represent germplasm** or raw materials that could be manipulated to design plants for specific purposes and needs (Dudnik *et al.*, 2001). Advancements in knowledge of seed formation and preservation has made it possible to intercept seeds at, or prior to, dispersal and store them in suitable conditions until they are needed.

2. ATTRIBUTES OF HIGH QUALITY SEEDS

To the ordinary man, the large differences in size, shape, and colour of crop seeds may easily be equated to large variability among seeds of different species. However, be it the pin head-sized seeds of *Amaranthus* spp. ('Tete'), the small-sized seeds of millets and sorghum, the, the medium-sized seeds of maize and cowpeas, the large seeds of *Telfairia occidentalis* ('Ugu') and oil palm or the huge seeds of coconut, seeds are far less variable at the level of structure and composition. Structurally, all botanical seeds have only three parts- an **embryo** which is the plant in a miniature form, **endosperm**, usually the store of food reserves for germination and a protective outer **seed coat**. While the endosperm and embryo are products of fertilization, the seed coat is entirely of maternal origin. The seed coat is a maternal tissue that derives from the ovary wall. Beyond the primary function of protecting the other structures as it restrict inflow and outflow of materials and the developing zygote, the seed coat is also the first line of defense against adverse external factors, it communicates environmental cues to the interior of the seed and this primes the seed to adjust its metabolism in response to changes in its external environment (Radchuck and Borisjuk, 2014).

According to Egli (1998) the seed has a dual function in agronomic crops- it serves as a planting seed to regenerate the crop and it is the organ harvested for economic yield. Unlike seed that is consumed as food and as industrial raw material and whose value lies in its nutritional or chemical composition, the value of a seed for sowing is in its livingness (viability) and its vigour. Thus, seeds for sowing must have a distinct identity from a traceable origin.

Unlike discrete traits like seed weight and thickness, '*seed quality*' is not a single measurable property. Rather, it embraces individual components each of which can be separately defined and assessed but which collectively provide an overall indication of the value and usefulness of a given seedlot for sowing purposes (Kelly and George, 1998). Such components encompass physical, biological, pathological and genetic seed parameters that ultimately have a bearing on plant performance and final yield of a crop in the farmers' fields (Esbo, 1980; Ellis, 1992; Burris *et al.*, 2002; Hampton 2002).

In relation to crop production, quality components are usually grouped into four:

- Genetic quality
- Physiological quality
- Sanitary quality
- Analytical quality

Genetic quality defines the identity of the seed and the success or failure of the crop. It encompasses innate attributes that are related to peculiarities of the seed both in general and specific terms. Yield-determining components like plant architecture, pest and disease resistance, and culturally-important plant traits such as colour, taste, productivity and adaptation of plants that will eventually be produced are all genetically determined and encoded in the embryo. Therefore, genetic quality typifies varietal characteristics. Physiological quality deals with two indispensable requirements of a seed, the need for it to germinate at the right time (viability) and to produce a strong and vigorous seedling capable of withstanding environmental stresses (vigour). Sanitary Quality relates to the freedom of the seeds from seed-transmitted diseases and other pathogenic organisms that can suppress the expression of physiological quality or affect the crop and prevent it from giving maximum yield. Analytical Quality is an important aspect that deals with the physical purity of the seed and is a measure of the proportion of a seedlot that is actually the seed of the intended variety. It measures the degree to which a seedlot is free from admixtures like seeds of other varieties of the same crop or other seeds of other crops, weed seeds, debris, inert matter (Louwaars, 1996; Almenkinders and Louwaars, 1999).

From the foregoing, it is evident that high quality seeds are technology packages carrying the outcomes of rigorous breeding and biotechnology efforts directed at optimizing crop performance or harvestable yield, or both. Such seeds are high in germination percentage and produce vigorous and strong seedlings that grow rapidly, tolerant of biotic and abiotic stresses, have competitive advantage and highly productive. The difference between dead and viable seeds, and between high-yielding, improved varieties of crops compared with landraces, is less in any discernible physical differences but more in innate potentials that are specifically bred and programmed into the seed for expression at, or after, planting.Low quality seeds germinate slowly, less non-uniformly and often produce low vigour seedlings. The crops resulting from such seedlings have less competitive advantage and are unable to withstand stress. This gives weeds more chance to develop and ultimately, harvestable yield and the quality of the harvest are poor with little market value.

Nigerian farmers are aware of the benefits derivable from the use of high quality seeds in food production. The results of a recent seed demand survey that we conducted across the six geopolitical zones revealed that more than 80% of farmers are sufficiently aware of the value of improved seeds in terms of vigour and yield potential (Ajayi, Unpublished data). Generally, farmers in the northern zones are more aware presumably because they have enjoyed government subsidy for agriculture more than their counterparts in the southern part. Curiously, the South-West region has the least awareness, the heavy presence of Agricultural Research Institutes in the zone notwithstanding. But in spite of the obvious benefits, the use of high quality seeds by Nigerian farmers is less than 10% (ATA, 2012). There is preponderance of the use of low quality, low-yielding, farmer saved seeds across Nigeria.With the exception of the North-East Zone, 65% of farmers claimed that high quality seeds were not readily available and were expensive. Hence, access and poverty are major factors limiting farmers' use of such seeds in Nigeria.

3. PRODUCTION OF HIGH QUALITY SEEDS

It is a dictum in seed science and technology that high quality seeds perform better than those that are of lesser quality. The main implication of this precept is that improving the performance of seeds in crop production is best achieved by concentrating on the development and production of high quality seeds and the maintenance of high quality through conditioning, storage, marketing and planting. High quality seed is the basis of higher agricultural productivity. But, high quality seed does not happen by chance and the production of such seeds is one of the most chronic problems facing the seed industry all over the world (Hill *et al.*, 1997; Desai, 2004; Basra, 2006; Black *et al.*, 2006).

The growth and development of the seed on the plant are the same whether the ultimate fate of the seed is to be planted in the soil to produce the next crop or be eaten or processed for food, feed or industrial purposes. However, the two seeds, plant seed or grain, are not equal from crop management viewpoint. The attributes of quality are not the same and consequently the management practices for producing high quality planting seed are not always the same as those used to produce seed for grain.

The main thrust of my research on seeds as agricultural input is the production and post-harvest handling of seeds of grain crops in order to guarantee high quality by minimizing damage (physical losses of quality) and deterioration (physiological losses). I have worked to elucidate the factors that influence the quality of seeds during production, processing, storage as well as the determinants of performance of seeds when sown in actual or simulated field situations. I have sought to provide answers to the following research question: What is the best indicator of seed maturity and how relevant is the concept of 'physiological maturity' to the physiology of seed quality? To what extent is this relationship influenced by biochemical composition of seeds at harvest? What are the contributions of different sequential mechanical operations to seed damage and how best to handle the operations. I have also extended my inquisition to the seed biology of neglected, underutilized species (NUS) in order to promote the propagation and conservation of these useful plant species that are not regularly cultivated but widely consumed.

One of the major seed production management decisions that affect the quality of seeds is the location and by inference the climatic conditions of the place where the production takes place. The production of quality seeds of a particular crop in an area and the failure in another depicts the influence of environment on seed development and maturation. Temperature and rainfall patterns are the two most important factors that must be considered in the choice of a location. The suitability of a location is assessed by evaluating the seed quality in relation to temperature and rainfall changes. From our work on maize and cowpea (Idowu, 2010; Akande *et al.*, 2012) the amount and distribution of rainfall has the greatest influence on seed quality. Rainfall received by cowpea during production played a more critical role in determining yield and disease incidence than date of planting. The planting date that gave optimal cowpea yield was not consistent over years. Unlike food production, quality rather than quantity, is the focal point in seed production and our results have shown that the modulating effect of environment are different for maximum seed yield (Figure 1) and seed quality (Table 1). As Adesina, Ajayi and Olabode (2012) showed, wrong timing and ineffective method of weed control in seed production fields can reduce the viability and vigour of maize seeds by up to 15 and 32%, respectively.

At outset of my career, there was a raging controversy on the direction and nature of the relationship between seed dry weight and seed maturity on the one hand and seed maturity and seed quality on the other. Without agreement on when a seed is mature, production of high quality seeds would be impossible. This is because seed producers traditionally use seed maturity, usually determined by the length of time to flowering, to make harvest decisions. Shaw and Loomis (1950) had coined the term 'physiological maturity' (PM) to

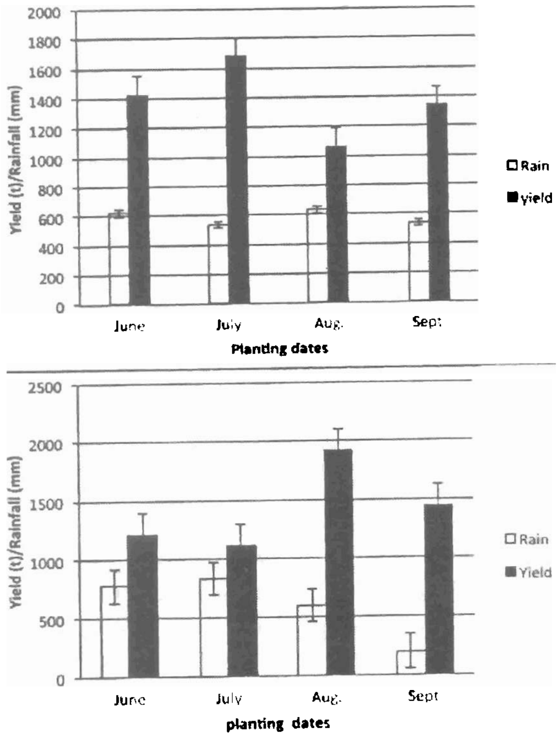


Figure 1: Average seed yield of four cowpea varieties planted on four different dates and associated rainfall received at Ballah, Ilorin in 2008 and 2009.

Source: Akande *et al.*, 2012

Table 1: Germination attributes of cowpea seeds averaged over planting dates

Germination Trait	Planting Date			
	June	July	August	September
Germination Percentage (%)	40.93a	48.27a	56.93b	58.93b
Germination index (days)	5.53a	5.18b	4.58c	4.72c

Means followed by the same letter in the same row are not significantly different (p<0.05)

Source: Akande *et al.*, 2012

denote the point at which a developing seed reached its maximum dry weight. Harrington (1972) extended this further by proposing that seed viability and quality also peaked at PM. This association of seed quality with the attainment of maximum dry weight guided agronomic seed research and commercial seed production for many decades and was the basis of harvest decisions. However, Professor Richard Ellis and his associates (Pieta Filho and Ellis, 1991a, b; Rao *et al.*, 1991; Ellis and Pieta Filho, 1992; Ellis *et al.*, 1993) at the University Reading in the UK opined that the term was misleading and that seeds continue to undergo physiological changes after the attainment of maximum seed dry weight. Another term, mass maturity, was therefore proposed to denote the point of maximum seed dry weight and the term physiological maturity for the point at which maximum seed quality was attained. However, Professors Dennis TeKrony and Dennis Egli (TeKrony and Hunter, 1995; TeKrony and Egli, 1997; Egli, 1998) both of the University of Kentucky in the USA, argued that there was no compelling reason to abandon the use of the term physiological maturity to refer to maximum seed dry weight. I recognized that the approach that these senior colleagues adopted in confirming or refuting the relevance of Harrington's hypothesis to the physiology of seed quality development was not going to provide a satisfactory and convincing solution to the problem. This then gave me a good entry point and the physiology of seed quality development and performance dominated my initial studies thereby affording me ample opportunity to make some contributions to the topic. I also had the privilege of meeting and sharing my perspectives with the three eminent professors at several scientific meetings in Spain, France and the USA.

Maize was used as a model crop in many of the investigations I carried out on the physiology of seed quality development. This is because maize is not only a staple crop, it is also the most widely adapted crop grown throughout the world under a wide range of climates (Maiti and Wesche-Ebeling, 1998; Paliwal and Smith, 2002). From the viewpoint of seed technology, agronomy, genetics, physiology, and biochemistry, it is a model experimental crop that had been studied extensively. It was the model plant for early works on seed development and reserve accumulation and its high multiplication ratio also made it suitable for large-scale seed production purposes.

In order to identify reliable indicators for timely harvest decisions in tropical environments, I investigated extensively the relationship between seed maturity and seed quality (Ajayi, 1997). Seed dry weight and visual indicators of its accumulation (milk line) or cessation (black layer formation) became popular as indicators of physiological maturity and extensive investigations had been done on their usefulness in temperate climates (Afuakwa and Crookston, 1984). As a result of the dearth of information on the usefulness of these indicators for seed production purposes in tropical environment, we compared dry matter accumulation, milk line and black layer formation as indicators of physiological maturity. Ajayi and Fakorede (2000) reported that the indicators gave different estimates of the time PM was attained in two single-cross hybrids of maize. We found that of the three indicators, milk line and black layer formation were not reliable and the results we obtained were totally at variance with similar ones from the temperate climates as reviewed by Afuakwa and Crookston (1984). We concluded that both milk line and black layer were highly subjective and that the degree of subjectivity was higher for black layer than for milk line.

In relation to seed quality, seeds harvested at weekly intervals from 31 to 59 days after silking, corresponding to different maturity stages, were not only evaluated for their inherent quality in laboratory tests but they were also subjected to field trials. As reported in Ajayi *et al.* (2001), we found that seed quality, measured by standard germination, field emergence and mature plant characteristics, was less dependent on seed dry weight. In laboratory tests, seed harvested before PM germinated faster than those harvested at or after PM. Furthermore, field emergence of seeds harvested weekly over five weeks, two weeks before, at, and two weeks after PM, showed no significant differences in quality. From this beginning we concluded that (i) the association of seed dry weight and seed quality for agronomic purposes was not as applicable as it had been generalized until then, (ii) no single indicator or combination of indicators was the best for seed quality and (iii) the usefulness of any indicator will depend on species and/or ecological conditions. Ajayi and Fakorede (2001) then called for a re-definition of PM at least as it applied to maize thereby aligning with previous similar suggestions by Ellis and Pieta Filho (1992) and Coolbear (1995).

Although our results provided baseline information from moist tropical environment to compare and complement over two decades data accumulated from temperate environments, they did not answer the question of what we could attribute the variation in the relationship among seed dry weight, seed maturity and seed quality to. This was aptly summarized by Hill *et al.* (1997) as follows:

> "The most obvious conclusion about much of the research on seed quality must be that it is generally inconclusive...Quite a lot is known about seed quality- we trade on it, we research it and we pay reverence to it. What we really need, however, is a clearer and more precise understanding of why and how seeds loose quality on the plant, at harvest, during processing and during storage, and to take into account the interactions between different storage conditions and seed's pre-storage history. Such an approach to the term 'seed quality' would give us clearer ideas on how to more fairly assess the planting value of seeds prior to sowing".

In order to address these challenges, I conducted extensive investigations on the physiological and biochemical basis of maize seed quality (Ajayi, 2003). It is well known that biochemical composition of seeds affects their quality. Maize genotypes with high contents of sucrose and other sugars, oil crops and crops where natural ratio of biochemical composition has been altered often have low seed quality (Cobb and Hannah, 1986; Douglass *et al.*, 1993; Parera *et al.*, 1996; Wilson and Mohan, 1998). But Ajayi (2003) noted that the relationship between seed maturation and the development of seed quality from a biochemical point of view had not received adequate attention in all the attempts to define the relationship between seed quality and PM. Many of the investigations on changes in seed composition during maturation in relation to seed quality had focused exclusively on desiccation tolerance (Chen and Burris, 1990; Blackman *et al.*, 1992; Leprince *et al.*, 1990; Wehmeyer *et al.*, 1996; Brenac *et al.*, 1997). In an exceptional case, Sinniah *et al.* (1998) examined changes in both soluble carbohydrates and heat-stable proteins during seed development and maturation in rapid-cycling brassica [*Brassica campetris (rapa)* L.] in relation to desiccation tolerance and seed quality. They observed that sugars and proteins were equally likely to be required for high seed quality development. The authors suggested that differences in seed quality among different commercial seed lots were more likely to result from differences in heat-stable protein accumulation than in sugars because deleterious environmental effects on seed quality development are usually detected late during seed maturation.

With respect to the development of physiological seed quality, Ajayi (2003) reported that seed moisture played a major role in the transition of seed from developmental to germinative modes. Specific seed reserve was associated with different seed quality component. For example, high physiological quality of maize seed was associated with a higher proportion of starch and lower proportion of protein, total soluble sugars, potassium and fibres. I concluded then that an important aspect of the physiology of seed quality was not just the amount, which is implied by the association of PM with seed quality, but the ratio of the stored reserves. This has been confirmed by the results from more recent studies in my laboratory on the physical and physiological determinants of cowpea seed quality (Okoh, 2015). High cowpea seed quality was associated not with the amount of any reserve (carbohydrate, protein, lipid) *per se* but with the lowest ratio of carbohydrate to protein. This occurred at least two weeks before cowpea is usually harvested, at a seed dry weight that was significantly lower than the maximum dry weight and at moisture content that was twice the minimum level that could be attained under natural field conditions to save cost of artificial drying. The high quality of the seeds in laboratory tests was also translated to higher emergence, seedling vigour and better crop performance in field trials.

Table 2: Influence of seed maturity on composition and quality of cowpea seeds

HD	SDW	MC	HSW	COND	CHO	PROT	CHO/P	GPCT	AAGPCT	EPCT	GR	DF50
14	1.64a	71.13a	6.00a	128.03a	80.51a	8.23a	12.35a	58.92a	13.00a	43.06a	0.21a	45.32a
21	3.44b	45.71b	11.20a	**58.07b**	**73.31b**	**16.22b**	**5.03b**	**83.67b**	**55.50b**	**70.84b**	**0.34ab**	**44.00b**
28	3.03c	**21.48c**	11.33a	77.27c	76.91c	11.68c	7.57c	53.92c	13.33b	37.95c	0.28b	44.67b
35	**3.80d**	23.31d	**11.38b**	104.49d	80.85d	8.75d	10.19d	21.17d	6.67b	12.69d	0.22b	47.2b
Mean	**2.98**	**40.41**	**9.97**	**91.96**	**0.49**	**7.87**	**8.95**	**54.41**	**22.11**	**41.20**	**0.26**	**45.30**

HD: Harvest Date; SDW: Seed Dry Weight; HSW: Hundred Seed Weight
COND: Conductivity; CHO: Carbohydrate Content,%; PROT: Protein Content, %
CHO/P: Carbohydrate-Protein ratio; GPCT: Germination, %; EPCT: Emergence, %
GR: Growth rate, g/day; DF50: Days to 50% flowering

Source: Okoh, 2015

The effect of drying temperature on this observation which was consistent in different cowpea varieties is being further investigated. Thus, while the quality of maize seeds was associated with higher proportions of carbohydrate and lower proportions of protein, quality of cowpea seeds was associated with lower proportions of starch and higher proportions of protein.

As reported in Ajayi (2003) and Ajayi *et al.* (2005a), we found that seed growth rate and seed growth duration, that is the interval between pollination and end of linear seed fill, exerted significant influence on maximum seed dry weight. Of the two factors the greatest influence came from seed growth rate and that there was no compensatory relationship between the two. That is, a prolonged duration of dry weight accumulation will not offset the limitation of a slower growth rate partly because the mother plant has a lifespan and is subject to the limitations of ecological conditions. Another major finding was that crops and varieties differed in which of the two strategies was more important for seed dry weight accumulation. Generally, late-maturing varieties tend to have slower growth rate but longer duration while early and intermediate varieties tend to have faster growth rate but comparatively shorter growth duration. We reported that even after maximum seed dry weight must have been attained, significant biochemical changes without seed dry weight changes were occurring in seeds all of which were affecting seed quality. This debunked the idea that the only change occurring in seed after attainment of maximum dry weight was dehydration. What distinguished my contributions to the already rich scientific literature on the physiology of seed on the one hand and the biochemistry of reserve deposition and mobilization on the other was the exploration of the inter-relationships among seed composition, seed quality and field performance together.

From the foregoing, it became apparent that the source of controversies surrounding the association of seed dry weight with seed quality was, first, the generalization of observations on one crop, under a given set of ecological conditions, to other crops or the attempt to extrapolate what is applicable in a crop to other crops of the same or other botanical classes. For example, the results on maize across wide ranging environments (TeKrony and Egli, 1997; Ajayi *et al.*, 2001b; Ajayi, 2003; Ajayi, 2003) did not agree with the results of Ellis and associates on wheat, barley and rice (Pieta Filho and Ellis, 1991a, b; Ellis and Pieta Filho, 1992; Ellis *et al.*, 1993) that cereal seed quality continue to increase after maximum seed dry weight. Whether a seed is harvested dry (for example cereals and legumes) or develops in fleshy fruits as in vegetables (Welbaum and Bradford, 1989; Demir and Ellis, 1992a, b; 1993; TeKrony and Egli, 1997) also affects the relationship between physiological maturity and seed quality. Thus, these differences are not necessarily contradictions rather, they reflect genetic quality differences and the specificity of the relationship between seed dry weight and seed quality in each crop.

Arising from the extensive data we generated from the preceding physiological and biochemical descriptions of the development of maize and cowpea seed quality, we concluded that defining the quality of a seed by its weight cannot be generalized. The hypothesis by Harrington (1972) that maximum seed quality, including viability and vigour, coincided with the attainment of maximum seed dry weight was not entirely supported by the results of my studies on the subject. Therefore, in relation to the association of physiological maturity and seed dry weight with seed quality it wasunequivocally concluded that there was no universal relationship and if any, it is crop- and genotype-dependent.

Influence of Mechanical Processing on Seed Quality

Mechanical seed harvesting and conditioning are done to enhance quality and prepare (or condition) seed for sowing. However, these processing operations cause mechanical damage to seeds. Such damage reduces seed quality due to internal and external injuries which may range from breakage and bruising to cracks and internal physiological damages.

Mechanical damage is caused by abrasions and impacts as seeds pass through series of machines from harvesting to bagging. Damage occurring during mechanical harvesting appears as horizontal cracks across the seed while damage occurring during drying appears as vertical cracks which can be detected with X-ray radiophotography (Thuy, 1999). Mechanical damage is not only caused by the use of machines. Damages may also occur at any of the intervening stages between harvesting and sowing. Stacking and banging of seed containers during handling and transportation are subtle but significant sources of direct physical injuries that affect seed performance or indirect injuries that are precursors of more deeply physiological problems

In the attempt to answer the question of how to produce quality seeds and handle them to maintain the high quality levels until they are delivered to farmers for sowing, I also did some pioneering work on the impact of mechanical damage to hybrid maize seeds from harvesting and conditioning (Ajayi *et al.*, 2002, 2006a). Prior to this study, information on the severity of damage caused by successive mechanical operations was limited and contradictory. Therefore, I provided a quantitative estimate of what each mechanical operation, namely mechanical harvesting, shelling, cleaning, and grading, contributed to damage of maize seeds in order to identify the operation that caused the greatest damage. Such information would be useful in designing and managing harvest and conditioning operations to minimize damage to finished seeds.

We found that the individual and combined contributions of mechanical harvesting and shelling did not cause a significant loss of maize seed quality prior to storage unlike mechanical cleaning and grading that caused between 20 and 40%, respectively. The severity of the damage occurring during grading was very high because internal physiological damages caused by agitations and vibrations occurred during this operation. But seeds carry these damages further which could only be detected in seed quality tests or after planting because there was no other post-grading operation during which such damaged seeds could have been sorted out. Irrespective of size, graded seeds had 38 times more dead seeds and 31 times more abnormal seeds than manually processed seeds (Ajayi, 2003; Ajayi *et al.*, 2006a). We also reported that flat and large seeds were more tolerant to mechanical damage than round and medium-sized seeds. The degree of susceptibility due to shape far outweighed susceptibility due to size. Farmers are now aware of the relationship between seed shape differences and quality to the extent that Mexican farmers prefer and pay higher prices for flat than round seeds because of the comparatively better performance of flat seeds (Batistel *et al.*, 2002).

Table 3 : Percentage losses in maize seed quality due to mechanical operations

OPERATION	VIABILITY		VIGOUR	
	Sole	Cumulative	Sole	Cumulative
Harvesting	0	2	2.20	2.20
Shelling	0.67	0.67	4.70	6.90
Cleaning	1.73	2.40	14.10	21.00
Grading- Medium	0.90	3.30	12.24	33.24
Grading- Large	0.03	2.43	2.79	16.79
Grading- Round	0.07	2.47	15.19	36.19
Grading-Flat	0	0	2.41	23.41

Values are mean of three replications and three hybrids

Source: Adapted from Ajayi (2003) and Ajayi *et al.* (2006a)

To date, these estimates are still reference points in discussions on the management of post-harvest mechanical operations of commercial seeds of grain crops. One of the reviewers of Ajayi *et al.* (2006), Professor Joseph Burris, who retired from Iowa State University, Ames, and is still considered an undisputed authority on the influence of mechanical damage on seed quality wrote me a personal mail to express his delight with the results. He claimed that that was the first time he was seeing such comprehensive seed industry data published in the public domain. He went further to request if I would be willing to continue research on mechanical damage to seeds where he left it. Since then, Professor Burris directs inquirers from all over the world on any subject relating to mechanical damage to contact me.

4. INFLUENCE OF SEED QUALITY ON SEEDLING ESTABLISHMENTAND CROPPERFORMANCE

For crop production to be successful, seeds need to germinate and thereafter emerge through the soil and the resultant seedling successfully established. Crop productivity, therefore, heavily depends on the availability of seeds with necessary quality traits that are required for successful establishment of a vigorous seedling capable of further growth into a productive mature plant.

A seedling is considered to be established when it has successfully transited from depending on seed reserves of carbohydrates, proteins, lipids and minerals to meeting its own food requirements through photosynthesis. This will naturally be preceded by the establishment of its own translocative apparatus for upward movement of nutrients from the soil to the aerial parts and of downward movement of photosynthates from the green parts, principally the leaves, to other parts. For maize, which I have worked with more than any other crop, this occurs after the formation of the fourth leaf (Ajayi, 2003; Ajayi *et al.*, 2005b).

A critical quality attribute of seed in relation to crop establishment is their vigour, that is the ability for rapid and uniform emergence as well as of rapid build of dry matter for subsequent growth. In the case of maize, Ajayi and Fakorede (2000), Ajayi *et al.* (2001a), Ajayi *et al.* (2005b) and Ajayi *et al.* (2006b) observed that seeds harvested prior to attainment of maximum seed quality usually responded to germination cues faster and by inference had lower emergence indices (or faster germination speed) than those harvested at maximum seed dry weight. Ajayi and Fakorede (2001a) postulated then that vital food reserves had been accumulated much earlier and that at the latter part of seed dry weight accumulation, more complex structural materials were being accumulated which would then require a complex catabolic pathway to break them down to sucrose, the form in which all stored food reserves are mobilized for utilization by the embryo during germination. Indeed, Ajayi *et al.* (2005b) showed that important physiological and biochemical changes occur within seeds after maximum seed dry weight was attained. Even when there were no apparent changes in seed dry weight, significant increase in the proportion of fibres at the expense of starch were observed and all these were translated not just to differences in seed quality but also to significant differences in field emergence characteristics.

Field performance potential of seeds is usually predicted with seed tests (Adedeji and Ajayi, 2014). I have contributed to the development of new and the refinement of existing techniques and procedures of seed testing (Ajayi, Fakorede and Owolabi, 2000; Ajayi and Fakorede, 2001b, 2007; Oluwaranti and Ajayi, 2008). But even when laboratory tests reveal significant seed quality compromise, high quality seeds have in-built mechanisms by which they counter the impact of deteriorative events and that when the conditions are appropriate, they have active mechanism for self-repair (Coolbear, 1995). This was clearly demonstrated in some of our studies (Ajayi, 2003; Ajayi *et al,* 2005a, b; 2006a, b) Thus, for agricultural purposes, a broad and balanced understanding of seed germination and of the physiology of seed performance both in laboratory tests and field trials are required for the interpretation of seed testing results otherwise type II errors would be committed in accepting false truths. On the basis of several field emergence and establishment studies that I have conducted both in Nigeria and abroad, I am unequivocal is asserting that the major cause of reduction in field emergence percentage is mechanical damage while primary cause of variations and loss of emergence speed is seed maturity.

Among conditions that are required for the expression of high quality seeds is a good and well-tilth soil that gives a good seedbed. Under traditional farming systems where there is a critical shortage of mechanical input, the achievement of a good seedbed is a herculean task. Irrespective of physiological quality, not all varieties have the genetic capability to emerge uniformly and rapidly and this was clearly demonstrated by our work on varietal differences in development of maize seedlings on compacted soil (Soyelu *et al.*, 2001). One of the major findings of this work was that the physiological mechanisms associated with seed emergence are totally different from those associated with seedling establishment in the field. Whether or not a seed will germinate and thereafter emerge through the soil and how long this will take is a function of the innate genetic traits and this could account for up to 85% of variability in emergence characteristics. But what developmental strategy the seedling will evolve in allocating its resources to root and shoot development are all highly dependent on environmental conditions including the level of soil compaction. We also found that unlike the conventional use of root elongation, the use of percent root dry weight, shoot length and shoot dry weight were more indicative of potential for seedling establishment in compacted soil.

The likely response of maize to emerging and forecasted changes in climate has also received attention in my research work. In this regard, maize has been evaluated for water requirement for seed germination and germination response to extremes of temperature. For germination to be initiated, maize seeds require moderate water, about 30-45% of the seed weight depending on temperature, unlike sorghum, rice, African yam bean, pigeon pea and okra for which we found water requirement prior to the initiation of seed germination to be 31, 31, 82, 96 and 160%, respectively. The lower the temperature, the lower the amount of water required by maize seeds but the longer the time to initiation of germination. The optimum temperature for seed germination was 25^{0}C. A 5^{0}C rise in temperature from 25^{0}C to 30^{0}C led to a significant increase in seed germination by 5% and a corresponding decrease in temperature decreased germination by 23% (Awosanmi, Ajayi and Fasusi, 2014). Also, the genotypes ranked differently under varying temperatures for germination percentage. We concluded that tropical maize genotypes will exhibit extreme germination response to decreased than to increased ambient temperatures. Thus, maize as a crop is expected to adapt well to the anticipated climate change-induced increase in ambient temperature.

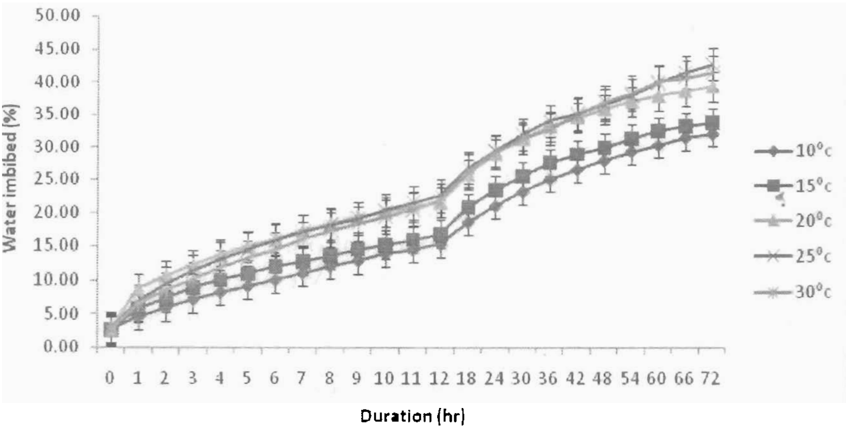


Fig 2: Percentage water imbibed by maize seeds averaged over four genotypes under varying temperatures
Source: Awosanmi, Ajayi and Fasusi (2014)

TABLE 4: Mean values for germination test of four genotypes of maize seeds under varying temperatures

Temperature (^{0}C)	GPCT (%)	GI (days)
10	0.00a	_
15	0.75a	8.92a
20	71.00b	8.06b
25	94.00c	5.52c
30	89.00d	4.36d

Means with the same letters are not significantly different

Source: Awosanmi, Ajayi and Fasusi (2014)

5. NEGLECTED UNDERUTILIZED SPECIES (NUS)

There are many useful but neglected underutilized species (NUS) that are pivotal to household food security but which are largely collected from the wild because many researchable constraints limit their cultivation. Such plants, usually indigenous, agro-ecologically resilient and collectively known as minor, orphan, underutilized, neglected crops or, crops for the future, contribute to food and nutrition security, income generation in rural areas, risk mitigation and building resilience to cope with climate change and economic limitations.

Many people that had the privilege of growing up in traditional or native communities still cherish vegetables like ebolo, amunututu, sokoyokoto, worowo, odu, ogunmo, ajefowo, osun, yanrin, eeku. We like to eat and would wish to have them on our menu but they are not available to buy once we are spatially isolated from our native communities. As useful as these plants are, they have been excluded from the food production and supply systems that have evolved with migration and urbanization and their cultivation for the benefit of a wider segment of the society can only be possible by alleviating the associated constraints.

My research activities on this topic have been directed towards highlighting how to (i) produce seeds of these 'orphan crops', especially African traditional vegetables and minor legumes, in order to promote their conservation through propagation and utilization; (ii) handle crops with recalcitrant (or desiccation-sensitive, non-orthodox) seeds and (iii) selection criteria for the development of varieties with high seed vigour. Neglected underutilized plant species that I have researched and for which we have successfully established protocols for alleviating the constraints to their incorporation into food production systems are Fluted pumpkin (Ugu), West African Okra (Ila iroko), Ebolo as well as minor legumes like African Yam bean and Pigeon pea (Ajayi *et al.*, 2006 c, d; Ajayi *et al.*, 2007 c, d; Olisa *et al*, 2010 a, b).

Fluted pumpkin(*Telfairia occidentalis* Hook. f.)

Telfairia occidentalis Hook. f., is a leaf and seed vegetable that is well-known for its high nutritional, medicinal and economic potential in the coastal areas of West Africa. The succulent, tasty leaves and stems, and nutritious seeds make it a vegetable to millions of people. Young shoots and leaves of *fluted pumpkin* are cooked, alone or in mixtures with other vegetables, and used as soups for different kinds of starchy doughs that are always in the daily meals of rural and semi-urban African populations. According to Abiose (1999), fluted pumpkin ranks as one of the three most widely eaten vegetables at homes and in restaurants in Nigeria. The fresh leaf concoction is a high-value health tonic for the treatment of acute anaemia (Akoroda 1990a; Schippers 2000). Immature seeds, eaten cooked or roasted, are preferred to mature ones because anti-nutrients increase with maturity (Akwaowo *et al.*, 2000). Seed cotyledons are also processed into seasonings, high-protein cake, marmalade, infant weaning foods, wheat flour supplement in making bread and different local fermented foods (Egbekun *et al.*, 1998; Giami and Isichei, 1999; Steinkraus, 2002; Giami *et al.*, 2003). Seeds are believed to have lactation-promoting properties and are in high demand by nursing mothers (Schippers 2000; Odiaka and Schippers 2004). Mature seeds are a good source of edible unsaturated oil (Esuoso *et al.*, 2000). Roots have high alkaloid content (Akubue, 1980) and their extracts are therefore used for controlling pest and rodents (Ajibesin *et al.*, 2002).

As it is with many other neglected underutilized species (NUS), farmers frequently have problems getting fluted pumpkin seeds to produce a good crop because they are unable to store fluted pumpkin seeds in the intervening period between fruit harvesting at the end of one season and planting at the beginning of another one, usually about four months. Seeds germinate and rot within fruits even before harvesting (Figure 3) and this is aggravated by prolonged storage of the fruits. When extracted from fruits, seeds do not store for more than a few days before viability is completely lost after about one week.

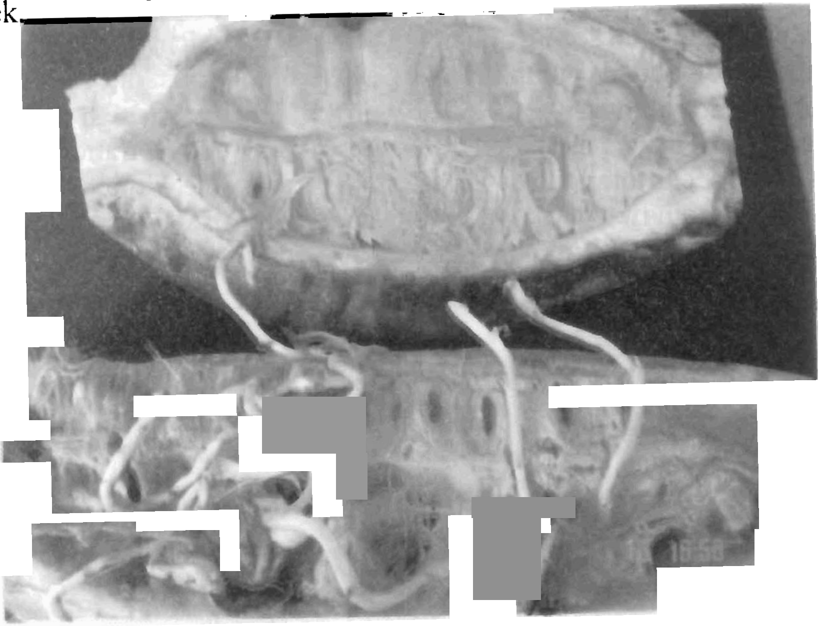


Figure 3: Germinating *Telfairia occidentalis* seeds within a freshly harvested fruit
Source: Ajayi (2005)

Thus, these biological constraints were not only limiting propagation but they also caused a gradual loss of the narrow and localized diversity, a situation that has resulted in the classification of fluted pumpkin as an endangered species (Sarumi, 2001). In order to arrest this trend my research has provided baseline information on the biology of the seeds, *in vitro* behavior and alternative approaches to conserving the diversity (Ajayi *et al.*, 2006b, c; Ajayi *et al.*, 2007b, c).

Typically, development of orthodox seeds is in three phases 1) histo-differentiation, 2) reserve accumulation and 3) maturation drying. But as the ultrastructure of the embryonic root meristem of excised axes from *T. occidentalis* seeds immediately after extraction from the fruit revealed, they were shed in an active metabolic state implying that the seeds did not go through desiccation drying. Viability of fluted pumpkin axes was rapidly lost at a water concentration above 1.0 g g^{-1} (50% wmb), which was too high for dry storage. Fast drying extended the range of water concentration over which the seeds tolerated desiccation (Figure 4). The marked loss of viability within two weeks of axes excised from seeds stored at 6°C suggests that fluted pumpkin seeds are also chilling-sensitive.

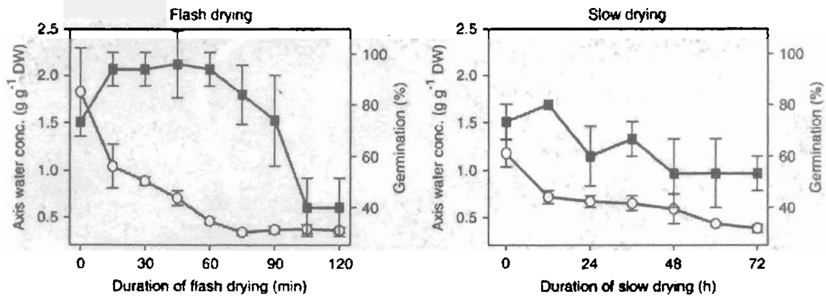


Figure 4: Drying characteristics of *Telfairia occidentalis* embryonic axes

—o— Water content —■— Germination

Source: Ajayi *et al.* (2006c)

Transmission electron microscopical observations revealed the seeds were indeed markedly chilling-sensitive, accumulating intracellular abnormalities at a temperature as moderate as 16°C within two weeks after being placed in storage, even though the effect was not then detected in the germination test (Figure 5). This implies that viability testing alone may be insufficient for characterizing chilling sensitivity in seeds. We concluded that fluted pumpkin seeds are shed at high moisture contents metabolically and owing to this, damage by desiccation to relatively high water

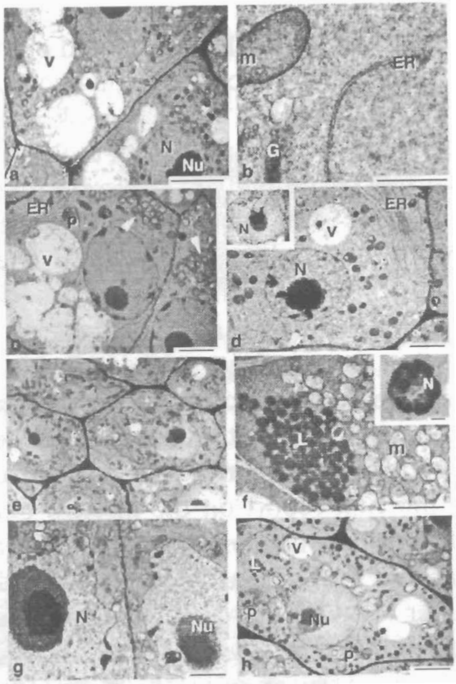


Fig. 5: Ultrastructural aspects of distal axis root tips cells (meristematic or immediate meristem derivatives) of *T. occidentalis* prior to (**a,b**), and after hydrated storage for 2 (**c-e**) and 4 weeks (**f-h**) at 6, 16 and 25°C. **a** (bar=5 μm): Cells from axes of fresh seeds were characterized by relatively small, discrete vacuoles and normally-dispersed organelles. **b**(bar= 0.05 μm): Mitochondria had relatively dense matrices and well-developed cristae, polysomes occurred associated with long profile of rough ER and dispersed in the cytomatrix, and Golgi bodies were prevalent. **c, d and e**: Cells from material stored hydrated for 2 weeks at 6, 16, and 25°C, respectively. **c** (bar= 2 μm): Intracellular derangement was already apparent in axes of seeds stored at 6°C, in terms of an abnormal degree of vacuolation (cf. **e**, 25°C) and displacement of clusters of organelles (arrowheads). **d**. (bar= 2.0 μm): Although axes from 2-weeks stored seeds at 16 °C, maintained viability, nuclei commonly contained patches of very dense material (possibly abnormally condensed chromatin) and in some cases, exhibited markedly lobed profile (inset, bar= 2.0 μm). **e**(bar= 5.0 μm): Axis cells from hydrated seeds stored at 25°C maintained ultrastructural normality. **f, g and h**: Distal root-tip cells of axes excised after 4 weeks hydrated at 6, 16 and 25°C, respectively. **f**(bar= 2.0 μm): Storage at 6°C was accompanied by ultrastructural derangement and organelle deterioration, while nuclei were shrunken and showed dense, compacted contents (insert, bar= 2.0 μm). **g**(bar= 2.0 μm): After 4 weeks storage at 16°C nuclear lobing persisted, and nucleoli were marked diffuse peripherally. **h**(bar= 5.0 μm): After 4 weeks of hydrated storage at 25°C, axis cells showed evidence that ongoing metabolism had occurred in terms of starch accumulation. The cells appeared to have maintained general ultrastructural integrity, although nucleoli were peripherally diffuse. ER, endoplasmic reticulum; G, Golgi body; L, lipid; m, mitochondrion; N, nucleus; Nu; nucleolus; p, plastid; v, vacuole **Source: Ajayi *et al.* (2006c)**

concentrations and sensitivity to chilling, fluted pumpkin seeds ar unequivocally recalcitrant, the second in the cucurbitaceae famil (Flynn *et al.*, 2004). High quality fluted pumpkin seeds cannot b stored below 16°C because of sensitivity to chilling and storage a temperatures above 16°C is unlikely to be useful for more than fou weeks because of the high metabolic activity of the seed on the on hand, and microbial proliferation on the other. The lowest wate concentration facilitating germination was too high fo cryopreservation as an alternative long-term conservation strategy.

In view of the categorical classification of fluted pumpkin seeds as highly recalcitrant and the attendant consequence that its conservation cannot be by seed storage but by in vitro means, Ajayi *et al* (2006d) was the first report on the *in-vitro* behaviour of the embryonic axes of *Telfairia occidentalis* noting that (a) germinating axes greened under low light intensity *in vitro* and the intensity of greenness was higher for partially-desiccated, compared with non-desiccated axes; (b) for the purpose of reducing explant size for cryopreservation, excised embryonic shoot tips germinated and grew roots when cultured on fortified full strength Murashige and Skoog (MS) basal · medium. However, the minimum water concentration to which excised embryonic axis of fluted pumpkin could be dried before germination declined was too high for cryoconservation. Our investigation on vegetative propagation was the first promising results indicating the possibility of vegetative propagation using vine cuttings as suitable explants.

From this initial success, we have refined the protocols for the *in-vitro* manipulations of the embryonic and vegetative explants and reported substantial progress in finding alternative propagation methods for fluted pumpkin (Sakpere *et al.*, 2011, 2014).

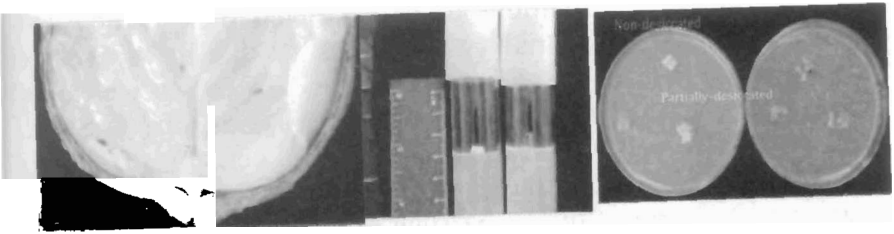


Figure 6: Zygotic axes growth on a fungicides + antibiotic-fortified medium 42 days after culture; greening of non-desiccated [1.83 g g^{-1}) versus fast-desiccated axes (0.71 g g^{-1}) one week after culture
Source: Ajayi *et al.* (2006d)

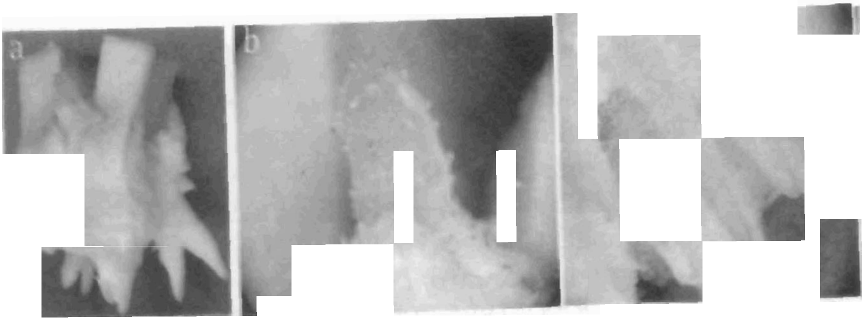


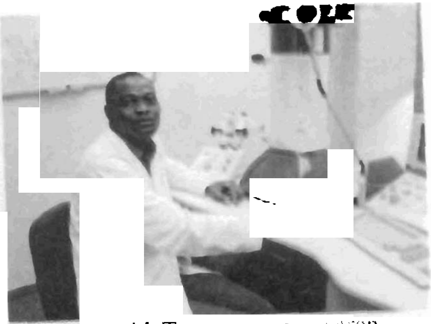
Figure 7:*In vitro* growth of excised shoot tips grown on medium fortified with 0.1 mg l^{-1} NAA and 2.0 mg l^{-1} kinetin (a) germinating shoot end (b) and rootlets radially growing on the periphery of the axes at the root end (c)
Source: Ajayi *et al.* (2006d)

6. BEYOND THE LABORATORY: WALKING THE TALK

My visibility and contributions are not restricted to this campus as I have also made substantial contributions to the growth of the Nigerian seed industry providing training and expert services to the regulatory body, the National Agricultural Seeds Council (NASC) as well as to members of the Seed Dealers Association of Nigeria (SEEDAN). I facilitated the take-off of the National Seed Testing Laboratory, an arm of the NASC that serves as the apex reference laboratory for the Nigerian seed industry. I nurtured the laboratory to its enviable state today having trained and recruited on behalf of NASC the Manager of the Laboratory. I provided mentorship and regularly visited the laboratory at the inception. I also trained many the other staff of the laboratory and its regional affiliates in all the six geopolitical zones. I have also visited all the regional laboratories at one time or another.

I have undertaken several country-level assignments for the United Nations Development Programme (UNDP) and Food and Agriculture Organization of the United Nations (FAO). I was a Thematic Group Leader for the preparation of Nigeria's Second National Communication to the United Nations Framework Convention on Climate Change (UNFCCC). I led the preparation of the Country Report on the *State of Plant Genetic Resources for Food and Agriculture (PGRFA), 1996-2008.* I was the National Consultant for Nursery Upgrading and Germplasm Collection on the FAO project "*Strengthening Plantain/Banana Production in Nigeria for Domestic Consumption and Export*" and the National Seed Expert for the just concluded project on *Strengthening National Seed Systems in Nigeria*". I was responsible for the preparation of the Revised National Seed Policy which was submitted only a few months ago. More than any other organization, the FAO afforded me several opportunities of working with smallholder farmers across Nigeria.

Working in Seed Testing Laboratory, Pioneer HiBred International, Parndorf, Austria



Working with Transmission Electron Microscope at the University of Kwa-Zulu Natal, Durban, South Africa

Opening Ceremony of a Seed Testing & Analysis Course organized by Prof. Ajayi for the National Seed Service (NSS)

DAAD-Alumni Workshop on Organic Farming, University of Hohenheim Stuttgart, Germany

With Professor Dr. Juergen Runge, Goethe University Frankfurtam Main, Germany

Field visit to smallholder vegetable farmers in Arusha, Tanzania

Supervising mechanical harvest-ting of commercial maize field in Halbturn, Austria

Participating in agenda-setting for research on underutilized plant species, Arusha, Tanzania

Working with smallholder farmers in Calabar, Cross-River State

Working with smallholder farmers in Asaba, Delta State

Both in the crop and livestock sectors, there is a growing recognition of the need to support smallholder farmers. In addition to my own background from a peasant farming family, the opportunities of working with smallholder farmers across the country has reinforced the need to support them with a publicly-funded position like the one I occupy. I also believe that being a professor is not an arrival as many erroneously believe, but the start of an academic journey which is interminable as long as the professor remains in an academic career. To this end, I have initiated the Smallholder Agricultural Support Programme (SHASP) and currently rallying private sector agro-processors that utilize agricultural produce as raw materials, in order to build synergies to help farmers. I believe that it is only when the interest of smallholder farmers have been adequately taken care of that Nigeria can be said to be truly transforming the agricultural sector. The dearth of mentors which was identified by Ajayi (2009) as one of the challenges facing young academics and professionals has spurred me beyond the normal call of duty to identify with aspiring young people as a role model. Some of those that I have mentored are prominent and active in both the public and private companies as CEOs, Managers and as University lecturers and research scientists across agricultural research institutions in and outside Nigeria.

CONCLUSION AND RECOMMENDATIONS

Mr. Vice-Chancellor, Sir, distinguished audience, I have enumerated some of the contributions I have made towards the production of high quality seeds of our major food crops. I have also demonstrated that quality seeds can be used as a basis for solving many agronomy-related constraints to sufficient food production, which is a basic minimum for the survival and prosperity of this beloved country. In spite of the changes in agriculture and the exciting opportunities that are accompanying these changes, what will remain as critical as ever before is that seed quality will remain the centrepiece of successful agriculture. Therefore, the transformation of the Nigerian

Agricultural sector needs to be de-politicised. It should not be seen as an agenda of a political party. Rather, government should pursue it with zeal and political will as a matter of national imperative.

It is most unlikely that large scale industrial farming will dominate Nigerian agricultural landscape because it would displace70% of the population from their land and livelihoods and majority of these rural dwellers would have to be employed in other sectors of the economy. Therefore, the cheaper and faster option for Nigeria's economic development is to tap its vast agricultural potential by designing policies and strategies targeted at improving the productivity of smallholder farmer systems. This approach will have a multiplier effect of reducing rural-urban migration, job creation, transformation of the rural communities, and reduction in poverty as has been successfully done in Brazil. If sustained, the on-going Agricultural Transformation Agenda (ATA) is first step in the right direction. Yet, the guarantee of input supply to smallholder farmers, which the Growth Enhancement Scheme (GES) is designed to address, will improve productivity of smallholder farmers but may not likely impact their living conditions unless the excess produce that will accompany the use of high quality seeds are mopped up by the private sector or kept in good storage. In view of this,

1. There is need to increase the national capacity for seed production and awareness towards promoting the use of high quality seeds. Governments of the Southern States of the country need to increase their commitment to the agricultural sector and provide more support to farmers in order to balance the tilt of more food production from the northern States.
2. An integrated seed supply system that allows plurality of seed sources for farmer is the best for Nigeria and National Agricultural Seeds Council need to work with other stakeholders to operationalize this. The formal seed sector is not reaching the majority of famers, the small-holders. There was a good conception of the community seed production

initiative but its implementation has not kept faith with the goal of growing and integrating it with the formal seed sector. The potential for high quality seed production by community seed producers has been aptly demonstrated in our study on the physiological quality of maize seeds from the informal seed sector (Odeyemi, Ajayi and Olakojo, 2010).

3. Market opportunities need to be created and partnership of the private sector strengthened in order to sustain the gain and build on the success of producing more food and industrial raw materials with the use of high quality seeds. This is because grain market drives the seed market. The creation of and accessibility to markets require a strong public-private partnership to drive. The dominance of agro-industrial businesses in Nigeria is an untapped market for raw and processed agricultural produce. This, together with the high demand for food by the >160 million inhabitants, provide a huge and ready market for whatever is produced in Nigeria aside the potential for export to the West African sub-region. However, access to markets for raw agro-industrial materials is highly restrictive to the detriments of farmers but to the benefits of middlemen.
4. Agricultural policies should be smallholder-friendly. About 80% of total food production comes from these farmers whose holdings are small and scattered and whose farming practices are subsistent and characterized by simple tools. The USAID-funded MARKETS II project which I served briefly as Agricultural Productivity Director in 2011 has developed a good and effective value-chain template for accelerating industrial growth, farmers' empowerment and job creation.
5. The organization of seed improvement in Nigeria is heavily tilted towards varietal development and testing. Quality control is very weak among public and private institutions and need to be strengthened. Less than 5 agricultural research and training institutions in Nigeria have trained seed technologist.

And in the entire Nigerian University system, seed scientists are less than 10. Given the regional specificity of our agricultural production system, the need for trained seed scientists and technologists in both the research and regulatory arms of the industry is apparent and urgent. In spite of the far less than satisfactory situation with respect to botanical seeds, the situation is far worse for vegetative seeds from which virtually all of our staple tuber crops are propagated.

6. Opportunities for curricular and short-term seed technology training should be expanded nationally because biotechnology will only accelerate but cannot and will not substitute for seed technology as long as botanical seeds remain the technology delivery system and agricultural input. The American and Canadian seed industries have issued warnings and expressed concern about the danger of scrapping seed technology programmes in Universities in the northern hemisphere (McDonald *et al.*, 1998; Harvey, 2006).
7. Obafemi Awolowo University should continue to support seed technology research and training in order to maintain our leadership position in this disciplinary area not only in Nigeria but across Africa. At the Special Senate Meeting held on 30th April 1986 where the Quinquennial Plan 1985-1990 was considered and approved, the establishment of a Seed Multiplication and Certification Unit was approved. I implore the University to fast track the establishment as an upgrade of our existing facilities.

8. ACKNOWLEDGEMENTS

Mr Vice-Chancellor, Sir, distinguished audience, I have laid claim to several achievements in the course of this lecture. But to claim all the glory will run contrary to the scriptural injunction in Jeremiah 9: 23-24:

Let not the wise man glory in his wisdom,
let not the might man glory in his might
Nor let the rich man glory in his riches,
But let him who glories glory in this, that he understands and knows Me that I am the LORD, excising loving kindness, judgement and righteousness in the earth.
For in this I delight says the Lord.

I wake up every day with a sense of awe and appreciation of the Almighty God, the invincible and Omnipresent God, the Father of the Lord Jesus Christ. Were it not for God's mercies upon my life through the knowledge of Him and of His salvation in Jesus Christ, I would have been unknown beyond the perimeters of Igbojaye in the northern part of Oyo State where I was born and raised. The Almighty God has lined the path of my life with helpers who have made the progression to this point in my life and career easier and I am making a public acknowledgement of this giving praise to Him to whom all my praise belong.

I am sincerely and deeply grateful to this institution, Obafemi Awolowo University, Ile-Ife, for giving me a platform for the expression of my innate and acquired skills. Beyond the breath-holding architectural and horticultural lay out of this University, it is an equal-opportunity institution where everyone, irrespective of status, ethnic and religious views, is given equal opportunity for expression.

I wish to thank the Vice Chancellor who, in both official and personal capacities, reposed so much confidence in me with the different responsibilities I have been privileged to bear in this University. No one has trusted me so much within a relatively short period of acquaintance and the opportunities have helped sharpen my skills.

The founding fathers and the successive generations of staff in the Department of Plant Science, now Crop Production and Protection, deserve my acknowledgement for laying a foundation of a good working environment devoid of factions, rancour and frictions, where issues, rather than people, institutional rules and regulations rather than sentiments guide decisions and interactions.

I wish to adulate the giants on whose shoulders I have stood to become this visible. I am blessed to have been born into a large family and raised in a community where a high premium was placed on cultural values and education despite that even the generation of my own parents did not have such opportunities and barely became literate through church-based adult reading and writing classes. I owe a lot to all my parents who did not only teach but copiously demonstrated to me the virtues of godly fear, hard work, contentment and communal spirit. Under them I grew to love nature in general and agriculture in particular. I wish to thank my parents, Pa John Taiwo and Mrs Ruth Oyeladun Ajayi who gave me nature and Late Pa Joseph Adeagbo and Mrs Racheal Ojeyoyin Ajayi who nurtured me from age 5. Since I became part of the Adeleke family, my parents-in-law have never ceased to pour prayers and prophetic utterances upon our lives.

All my siblings loved me unconditionally and I am grateful for the rich memory that we have shared together and the sense of pride they have all given me as one of them. Their individual and collective support are beyond enumeration and they have in no mean way made my journey this far possible. I wish to single out my elder brother

Bamidele Ajayi and his wife for paying for my General Certificate of Education Examination and thereby spared me the hard choice of either being a firewood collector or a panel beater.

Although I have lost contact with him about 30 years ago and my relentless search both here, in Ghana and elsewhere have not yielded any positive result, Mr. Isaac Boachie Yeboah, my Mathematics and Geography teacher in secondary school deserve a special mention at an occasion like this. While in the midst of a group of innocent but unguided pals on a self-destruction mission of hunting for girlfriends under the cover of darkness at age 12 one fateful night, Mr Yeboah met us and having noticed my declining school performance snatched me from the group. Taking advantage of our living together under the same roof, he never allowed me to be out of his reach day and night after that encounter. He went as far as detaining me in school to be by his side studying after others had left. He barely allowed me time to eat after school before locking me inside until the village had gone to bed and waking me up to read late into the night. He personally coached me for the UME and his efforts are better appreciated against the background that out of 100 of us that wrote the GCE in my school, only four of us had pass grade in English Language. I was blessed to have Rev. D.A. Adekanmbi as my Bible knowledge teacher and also as my class teacher in the final year of my secondary school. He not only taught us the knowledge of the word of God as a school subject, he also demonstrated it as a teacher. Living together in Ile-Ife has afforded him opportunity to not only be praying for me but also delight in my progress.

At the point of seeking admission after secondary school, the fear of chemistry which I barely managed to pass drove me to social sciences. It was the insistence of Dr. O.O. Ogunsola, the beacon for educational aspirations in Igbojaye, and the facilitation of Mr. Banji Aiki that my advanced level admission to Oyo State College of Arts and Sciences was changed from Economics/ Government/ Mathematics to Biology/ Chemistry/Mathematics.

Among numerous academic and spiritual teachers and mentors, Professors T. Olutunla, J.L. Ladipo, A.E.Akingbohungbe, M.A.B. Fakorede, A.A. Adebayo, O.O. Obi, B.A. Matanmi, W.A. Akinsola, E.B Sonaiya, I.O. Obisesan, O.A. Akinyemiju, O.T. Akinrinade,A.A. Adediran, K. Ako-Nai, J.A. Fabayo, T.A. Olugbade, A.T. Salami and Ambassador Ayo Ayodele took exceptional interest in my career progression and my relevance to this institution. They believed in me more than I believed in myself and went out of their way to push me to aim high. They imbued in me the institutional spirit of giving all to the survival of this system in return for the opportunity that the Obafemi Awolowo University affords each and every one of us not only to earn a living but to find expression.

I have enjoyed to date the support and collaboration of Drs. A. Menkir, S.O. Ajala and B. Badu- Aprkau of IITA, Professor Hugh Pritchard and Dr Moctar Sacande of the Seed Conservation Department, Royal Botanic Gardens, Kew, UK; my post-doctoral research host, Late Professor Patricia Berjak of the University of Kwa-Zulu Natal, Durban, South Africa, Professor Miller McDonald of Ohio State University, Dr. Ina Pinker of Humboldt University, Berlin, Prof Dr. Jurgen Runge of Goethe University, Frankfurtam Main and my doctoral supervisors Dr. Gerhard Ruehl and Prof. Dr. Joerg Greef of the Institute of Crop and Soil Science, Julius Kuehn Institute (JKI), Brauschweig, Germany.

I have worked very closely and enjoyed my collaboration with Dr. S.A. Olakojo of IART, Ibadan and together with highly motivated graduate students that I have had over the years, we have endeavoured to raise the bar for seed technology research and training in Nigeria.

I joined Beulah Baptist Church in Ibadan Road as a teenage student and from then to date, I have been nurtured, cared for and admired. I found mentors, brothers, sisters, and parents there and it is fitting to acknowledge the spiritual and emotional stabilities that my membership has afforded me to be able to build a career.

Unknown that she would one day be the beneficiary of her advice, my wife, Yemi, was among the first to spot my scholastic potentials. Right from our advanced level mathematics tutorial classes, she encouraged me to consider an academic career path. Together with our children, Ayooluwatomiwa, Aanuoluwatimileyin, Oluwatomiisin and Oluwatomilola, they allowed me unrestricted space to flourish and pursue my call and passion. I wish to thank them most sincerely for supporting me at great personal sacrifices.

Mr. Vice-Chancellor Sir, distinguished audience, thank you for your attention and for the honour of your presence here today. May the Lord bless you all.

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