PHYTONEMATOLOGY: SMALL ANIMALS, BIG IMPACT

An Inaugural Lecture delivered at the University of Ibadan

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by

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The Vice-Chancellor, Deputy Vice-Chancellor (Administration), Deputy Vice-Chancellor (Academic), Registrar, Librarian, Provost of the College of Medicine, Dean of the Faculty of Agriculture and Forestry, Dean of the Postgraduate School, Deans of other Faculties and of Students, Distinguished Ladies and Gentlemen.

In the Beginning

I want to start this inaugural lecture with a short true story. About 48 years ago, almost to the date, I wrote my very first test in General Science as a Form 1 student in the world-famous Government College, Ibadan (GCI). The test question was "What are the branches of Science?". I smiled to myself at the cheapness of the test and then proceeded to provide answers to the question thus: "The branches of science are Ibadan, Lagos, Kaduna, Kano, Benin, Ilorin, Sokoto, Enugu, Calabar, etc". I ensured that all major cities from each of the then existing three regions were represented in my list. I got tired after listing about 25 major Nigerian cities and I was sure that I had done enough to satisfy the General Science teacher.

Of course, I got a zero when the results of the test came out because the expected answer was Chemistry, Physics and Biology. Not only did I get a zero, I was also caned, made to write an imposition and given a portion of grass to cut. I believe that I also got a tongue-lashing from the teacher and, in the process, was called a "Ne'er-Do-Well".

Mr. Vice-Chancellor, Sir, distinguished ladies and gentlemen, between January 1961 and now, a lot of water has passed under the proverbial bridge. But the honest truth is that I still cannot correctly answer this question. While I may now no longer list Nigeria's major cities as branches of science, I honestly do not have a comprehensive list. In these days of sophisticated and high-tech methodology and instrumentation, the defining borders of the branches of science are getting wider and wider by the day to the extent that previous disciplinary subsets have all evolved into major branches of science themselves.

What are the branches of Science? Mentioning just Chemistry, Physics and Biology is no longer an acceptable

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answer to this question. Under Chemistry, specializations include, amongst others, Organic Chemistry, Inorganic Chemistry, Analytical Chemistry, Industrial Chemistry, etc. Only about seven weeks ago, Professor Olusegun Ekundayo, in his inaugural lecture (Ekundayo 2008), added *aromacology* to the ever-growing list. Physicists specialize in Space Physics, Nuclear Physics, Solid State Physics, Condensed Matter Physics, Lower Atmosphere Physics, Health & Radiation Physics, etc. The specializations under Biology are even tremendously more; Botany, Aquaculture, Physiotherapy, Neurosurgery, Obstetrics, Microbiology, Physiology, Ophthalmology, Gynaecology, Zoology, Molecular Biology, Cardiology, Urology, Paleontology, Oncology, Mycology, Virology, Radiology, Helminthology, Entomology, Phytonematology, just to name a few of the …logies. Note, Sir, that I have not even mentioned the specializations in Technology, Mathematics or, even the Social Sciences. Thank God, that we don't have a tradition of caning in the university system. Otherwise, I would have had to be caned like I was in 1961 for failing to correctly list the branches of science.

Mr. Vice-Chancellor, Sir, Distinguished Ladies and Gentlemen, "What are the branches of Science?" May be that is the topic for a future inaugural lecture, or perhaps, a Postgraduate School discourse. For this particular inaugural lecture, however, I shall restrict myself to that branch of science known as Phytonematology.

Well, to the glory of God, the Ne'er-Do-Well of 1961 is today's inaugural lecturer at the great University of Ibadan. This is the 6th in the series of inaugural lectures in the university for the 2008/09 academic session. It is the 34th from the Faculty of Agriculture and Forestry, and the 8th from the Department of Crop Protection and Environmental Biology (formerly known as the Department of Agricultural Biology); coming after Professors T. Ajibola Taylor (1974), A. Youdeowei (1977), N. O. Adedipe (1979), O. F. Esuruoso (1982), M. O. Adeniji (1984), J. K. Egunjobi (1990) and J. A. Odebiyi (2004). However, it is the very first to be given in this university by a thoroughbred phytonematologist. One or two people even tell

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me that it is the first phytonematology inaugural lecture in the entire Nigerian university system.

Let me conclude these preliminary remarks by saying that it is, indeed, a great honour for Dele T. @ 60 to stand before this august gathering and be giving one of the UI @ 60 inaugural lectures. I express my sincere gratitude to my Head of Department who nominated me for this assignment.

Phytonematology

Phytonematology, very simply defined, is the study of plant-parasitic nematodes (PPNs). The next logical question, therefore, is, What are plant-parasitic nematodes (PPNs)?

PPNs: General Considerations

PPNs belong to the Animal Kingdom and they are agricultural pests which, along with others like fungi, bacteria, viruses, weeds, insects and rodents, do not allow agricultural crops to produce at the optimum. PPNs are unsegmented, microscopic, and, with a few exceptions, are not visible to the naked eye. They come in various shapes but are mostly worm-like organisms that possess stylets with which they derive their nutrients from the plants they attack. PPNs are mostly root parasites but they can attack other parts of the plant such as storage organs, stems, leaves, flowers and seeds. Symptoms of nematode attack, especially on above-ground plant parts are usually nondescript and are similar to those caused by other plant pathogens such as fungi, bacteria, viruses; or those of water and nutrient deficiency.

Above-ground symptoms include chlorosis, stunting and malformation of plant parts, wilting, especially on hot sunny days, reduced foliage, branch dieback, early senescence and, in severe cases, total crop failure. Below-ground symptoms tend to be more specific and diagnostic, and include root necrosis, root rot, root malformations, especially root galling, decay of storage organs such as tubers, corms, bulbs, etc. I am sure that many housewives are very familiar with yam decay and the need to peel off often substantial portions of the tuber before cooking.

PPNs are very widely distributed. Indeed, any habitat that supports plant life will also support a population of one type of

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plant-parasitic nematode or the other. Most nematode problems tend to be associated with, but are not limited, to coarse-textured soils. The nematode life cycle consists of the egg, four juvenile stages and the adult male and female. Reproduction is usually by sexual means but pathenogenetic mechanisms (reproduction without fertilization of the egg) also occur.

The degree of damage caused is usually directly associated with the population density of the particular nematode i.e. the higher the number of nematodes, the higher the level of damage. The adult females also tend to be more damaging than the adult males for many nematode species. PPNs also interact with other plant pathogens, especially fungi, in disease complexes and some are known to transmit plant viruses. The overall effect of their attack is to reduce plant yield (quantity) and quality, and consequently, farm income.

Nematode Parasitism

A special attribute of all PPNs is that they all possess a structure known as stylet. This is a spear-like structure and it is with this that the nematode punctures and damages plant cells. It is hollow and is used in feeding by the nematode. There are two types of stylets: the odontostylet and the stomatostylet and they are of taxonomic significance.

PPNs are obligate parasites i.e. they must feed on susceptible plants for them to complete their life cycles. Broadly, PPNs are classified as either ectoparasites or endoparasites, each of which can either be migratory or sedentary. Once sedentary PPNs have established a feeding site, they will no longer move about, while the migratory PPNs change their feeding sites as they move from one location to the other. Some migratory endoparasites are even known to freely migrate between the rhizosphere and plant tissues.

Ectoparasitic PPNs are those that remain on the surface of the plant root and feed by inserting their stylets into cells around the head of the nematode. Some of the common ectoparasites have very long stylets which enable them to reach deeper into the plant root. Some examples of ectoparasites are *Helicotylenchus* spp., *Trichodorus* spp., *Xiphinema* spp., *Longidorus* spp., *Hemicycliophora* spp., and *Criconemoides*

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spp., just to name a few. Endoparasites are those PPNs which penetrate and feed within the plant tissues. There are those that feed on only cortical cells while some others are associated with the plant vascular tissues. A few examples of endoparasites are *Meloidogyne* spp., *Heterodera* spp., *Globodera* spp., *Pratylenchus* spp., *Radopholus* spp. and *Scutellonema* spp. There are a few PPNs known to be semi-endoparasitic, in which the nematode body only partially penetrates the plant root leaving a large proportion of the nematode body projecting into the soil. Examples of semi-endoparasites are *Rotylenchulus* spp. and *Tylenchulus* spp.

Research in Phytonematology

For almost four decades or so, I have worked extensively with various PPNs. However, the major nematodes I have worked with have been the root-knot nematodes, *Meloidogyne* spp. *Meloidogyne* spp. are sedentary endoparasites and are, perhaps, the most important nematodes world-wide. Four root-knot nematode species are important world-wide and they are *M. incognita* (Mi), *M. arenaria* (Ma), *M. javanica* (Mj) and *M. hapla* (Mh). Three of the four major root-knot nematode species; Mi, Ma and Mj are found all over Nigeria. However, Mi predominates in southern Nigeria while Mj is found mostly in northern Nigeria.

In phytonematology work, areas of research include

- Nematode taxonomy, systematics and classification
- Diagnostic surveys
- Crop loss assessment studies
- Morphological studies
- Biology studies
- Ecology studies
- Physiological and Biochemical studies
- Nematode control studies

I have been involved in all but the first of these areas of research. The rest of this inaugural lecture will be structured along these lines of research areas and, in the process; I shall highlight some of my contributions to knowledge in the branch of science known as phytonematology.

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Diagnostic Surveys

These are studies carried out to establish nematode-crop associations. They do not necessarily indicate the importance of plant-parasitic nematodes in such associations. Diagnostic surveys help to identify those nematodes associated with the roots (or other parts) of that particular crop and which may have potentials for transforming into major pests when the conditions are right. Very often, nematode populations in agricultural soils are polyspecific i.e. many different types are found together. Consequently, controlled pathogenicity tests have to be carried out to determine the damage potential of each of the identified nematode species.

Several diagnostic surveys have been carried out since the pioneering work of Caveness (1965). The collation of our work and those of many others since then gives the list of plant-parasitic nematodes associated with some major crops in Nigeria (table 1.)

Table 1. Plant-parasitic Nematodes associated with Some Major Nigerian Crops

Crop	Associated Nematodes
Maize, sorghum and millet	*Pratylenchus zeae, P. sefaensis, P. brachyurus, Hoplolaimus* spp., *Meloidogyne* spp., *Xiphinema* spp., *Longidorus* spp.
Rice (swamp & upland)	*Hirschmaniella oryzae, Aphelenchoides besseyi, Meloidogyne* spp.
Yams (*Dioscorea* spp.)	*Scutellonema bradys, Meloidogyne incognita, Pratylenchus brachyurus*
Sugarcane	*Heterodera sacchari, Meloidogyne* spp.,*Helicotylenchus* spp., *Pratylenchus zeae*
Bananas and Plantains	*Pratylenchus* spp., *Radopholus similis, Meloidogyne* spp., *Helicotylenchus* spp.
Tomato (and most other vegetables like okra, pepper, etc)	*Meloidogyne* spp., *Helicotylenchus* spp., *Rotylenchulus reniformis, Pratylenchus* spp., *Hoplolaimus* spp.,
Cowpea	*Helicotylenchus* spp., *Meloidogyne* spp., *Hoplolaimus seinhorsti., Rotylenchulus reniformis, Pratylenchus brachyurus*
Soybean	*Meloidogyne* spp.
Pineapple	*Meloidogyne* spp., *Helicotylenchus* spp., *Rotylenchulus reniformis, Pratylenchus* spp., *Hoplolaimus* spp.,
Tree crops (Citrus, Cocoa, Oil-Palm, etc)	*Xiphinema* spp., *Criconemoides* spp., *Hemicycliophora* spp., *Dolichodorus* spp., *Tylenchorhynchus* spp., *Meloidogyne* spp.

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One major contribution that was made in this research area was to take a closer look at the report of some entomologists from the University of Jos (Onwuliri *et al.* 1988) who reported the presence of potato cyst nematodes, *Globodera* sp. on Irish potatoes in two farms in Plateau State. Potato cyst nematodes are very harmful to the crop and are also very difficult to control. Consequently, they constitute a major threat to the potato industry all over the world. If truly present, then the potato industry in Plateau State was doomed. Secondly, the nematode had not been previously reported in Nigeria. It was therefore very important to ascertain the veracity of the report by the UniJos entomologists.

Fawole and Awogboro (1990) carried out an extensive survey of the potato producing areas of Plateau State and, happily, did not find any cyst nematode associated with potatoes in the State. They found lots of root-knot nematodes and concluded that Onwuliri *et al.* (1988) must have mis-identified the root-knot nematodes as cyst nematodes. Fawole and Awogboro (1990) also concluded that nematology studies should preferably be left to nematologists.

Crop Loss Assessment Studies

Crop loss assessment studies help to establish the importance of a particular plant-parasitic nematode on a specific crop through a determination of the effect of the nematode on crop productivity. They also help to establish threshold populations for specific crop/nematode combinations. For example, Afolami and Fawole (1991) established that 1,750 individuals of *Pratylenchus sefaensis* per 250 ml of soil would significantly reduce maize yield.

Crop loss assessment studies are usually carried out in controlled situations, mostly in growth chambers or greenhouses, in which the particular PPN under investigation is the only stress factor on the plant. They can also be carried out in the field using concrete or plastic microplots; or directly, when a particular PPN is dominant. However, while these studies generate useful information on the impact of the PPN on the crop under specific plant growth conditions, they do not indicate plant behaviour in the presence of interacting plant

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stresses such as other pests and unfavourable environmental conditions.

In general, crop losses tend to range from slight or non-existent to total crop failure. Indeed, one of the reasons for the collapse of the Bacita Sugar Industry in Kwara State is the presence of a PPN. Several sugarcane fields in Bacita had to be abandoned because of the ravaging effects of the sugarcane cyst nematode, *Heterodera sacchari*.

Plant age at exposure to nematode populations, nematode population density, crop growth factors such as light intensity, soil moisture and soil nutrition and the type of nematode are all important factors that will influence the severity of the crop loss (Fawole and Mai, 1977, 1988; Fawole and Fajemisin 1988; Fawole and Raji 1988; Idowu and Fawole 1992; Ononuju and Fawole 1999; Fawole and Claudius-Cole 2000; Nwanguma and Fawole 2001).

Morphological Aspects of Parasitism

As earlier stated, each PPN possesses a stylet. In establishing a feeding site, the PPN thrusts its stylet vigorously and this results in the damage of the cell. In addition, some of the endoparasites migrate intercellularly and intracellularly, in the process further destroying the cells of the infested plant. This activity can lead to profound effects on the plant. Figure 1 below shows the influence of the root-lesion nematode, *Pratylenchus zeae* on maize roots. In some nematode-crop associations, the plant cells become necrotic and later die. When the infestation is heavy, the root system is mostly destroyed, and eventually the plant dies. In other nematode/crop relationships, there are transformations of the cells into a syncytium (fig. 2) on which the nematode feeds for the rest of its life. The transformed cells also do not function normally. The overall effect of all cell abnormalities is that they do not function at optimum, to the detriment of the expected productivity of the plant.

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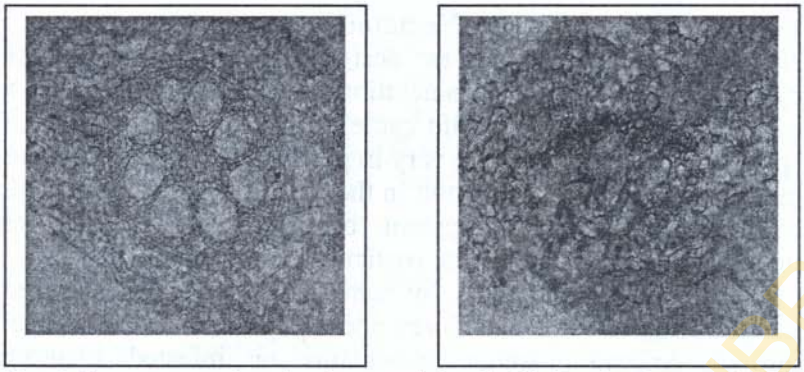

Fig. 1. Transverse section of maize root infested with *Pratylenchus zeae* (right). Healthy root is on the left. (Photo by Edward Oyekanmi)

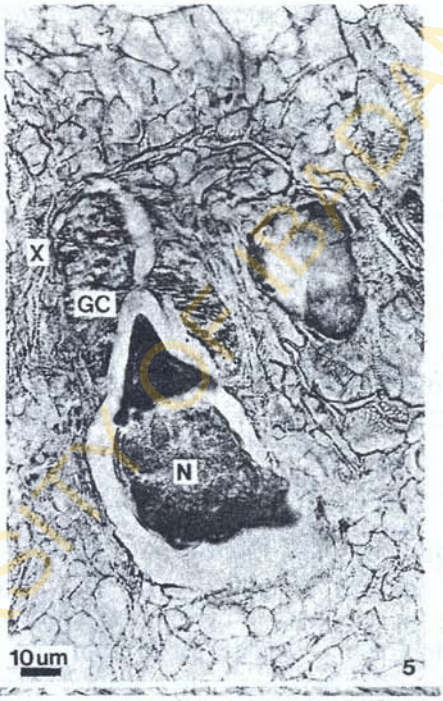

Fig. 2. Giant cell (GC) induced by *Meloidogyne incognita* (N) in *Dioscorea rotundata* tuber. X = xylem. (After Fawole 1988)

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Biology of Plant-parasitic Nematodes

Nematode Biology studies are designed to understand the life cycle of the nematode; its generation time (the period it takes a nematode to complete its life cycle), mode of survival, how it spreads, etc. The studies are very important because they help to elicit the most vulnerable point in the nematode's life cycle and, consequently, the development of appropriate control or management strategies for the particular nematode.

PPNs are spread mostly by man and his activities; infested soil adhering to farm machinery and equipment used in tillage, through irrigation water, transplants or infested planting materials. For example, Nwauzor and Fawole (1990, 1992) investigated the development and life cycle of root-knot nematodes in yam tubers and found *Meloidogyne incognita* eggs and juveniles as deep as 14mm from the peridermal surface in infested yam tubers. These eggs and juveniles were able to survive a 16-week storage period. Thus, they are able to serve as sources of inoculum when such tubers are used as planting stock.

Temperature is the principal factor influencing the life cycle of plant-parasitic nematodes. In general, the generation time is about 28 days at 30^0C for most nematodes. The generation time usually takes longer at colder temperatures and vice versa.

Volunteer crops and susceptible weed hosts serve to carry over populations of PPNs from one cropping season to another. Fawole (1972) found the reniform nematode, *Rotylenchulus reniformis* on some weeds such as *Commelina nudiflora* during the dry season.

Ecology of Plant-parasitic Nematodes

These studies are complementary to Biology Studies in that they help to give an understanding of the factors that influence growth, development and behavior of plant-parasitic nematodes in response to different biotic and abiotic components of the environment. In other words, how do temperature, moisture, availability of oxygen and other soil factors, as well as the other organisms with which they share the same environment influence their activities and survival?

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Soil moisture and temperature have been shown to be the major abiotic factors affecting the growth, development and reproductive ability of most nematodes. Ononuju and Fawole (1997) showed that soil moisture content was the primary factor influencing populations of *Meloidogyne incognita*, *Pratylenchus pratensis*, *Helicotylenchus multicinctus*, and *Scutellonema bradys*, found associated with plantains in Southwestern Nigeria.

A rule of thumb is that most PPNs in the Tropics thrive at temperatures between 20^0C and 30^0C. Outside this range, nematode activities are inhibited. However, below 5^0C and above 40^0C, the temperatures tend to get lethal, especially if the nematode is exposed to that temperature for a long time. This factor is exploited in nematode management.

Physiological and Biochemical Aspects of Parasitism

These areas of research generally have not received as much attention as the other areas. The studies address the effect of plant-parasitic nematodes on the physiological processes of the plants they attack, as well as the changes they induce in the chemical composition of the plants and their products that get harvested. These changes (physiological and biochemical) are never obvious. When PPNs attack susceptible plants, the physiological efficiency of the roots to function is impaired; leading to decreased rates of water absorption, translocation and photosynthesis in affected plants, as well as higher rates of respiration in infested stored produce.

Fawole and Evans (1989), using an electrochemical gas sensor, studied the rates of oxygen uptake in *M. incognita*-infested and non-infested yam tissues and found that the rate was higher in the infested tissues. The implication of this is that the rate of deterioration (weight loss and decay) is faster in nematode-infested tubers than in apparently healthy ones. Nwanguma and Fawole (1996) reported a decrease in water potential in *Meloidogyne incognita*-infected tomato as the period of infection increased. This decline in water economy is influenced by the number of PPNs and the variety of the tomato plant. Also, it has been reported that plant roots with galls shift metabolism in the direction of protein synthesis and also show a

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reduced transportation of growth regulators. In addition to photosynthesis, respiration and water relations, other aspects of physiological parasitism requiring attention include nitrogen assimilation, nutrient partitioning, etc.

Biochemical studies, on the other hand, are designed to determine the effects of parasitism on the chemical compositions of plants as well as the food value of affected plants. In root-knot nematode-infested tissues, the amounts of carbohydrates, pectins, cellulose and lignin decreased to varying degrees compared to non-infested tissues. Alternatively, the proportions of hemicelluloses, organic acids, free amino acids, nucleotides, RNA, DNA, lipids and minerals in the infested plants increased to varying levels. Certainly, collaboration with plant physiologists and biochemists in these areas will be very welcome for a fuller understanding of the effects of PPNs on chemical compositions and physiological processes in affected plants.

Management of Plant-parasitic Nematodes

Several management options are available for the control of plant-parasitic nematodes and these include both chemical and non-chemical means. Chemical control, with nematicides, give the most effective and rapid nematode control. Several nematicides are available (as fumigants and non-fumigants), and have been used for the control of PPNs on various crops. For example, Ononuju and Fawole (2000) used ethoprophos (Mocap 10G), isazophos (Miral 10G) and carbofuran (Furadan 10G) to control *Meloidogyne incognita, Pratylenchus pratensis, Helicotylenchus multicinctus* and *Scutellonema brachyurus* on plantain. In addition to a significant reduction in nematode populations, plantain bunch weight in nematicide-treated plots was about double that in the non-treated plots.

However, most nematicides are often very expensive, highly toxic and usually leave lasting residues in the soil. Indeed, many of the common nematicides are no longer approved for use in the developed countries. Consequently, there is now a shift towards less expensive, ecologically-sound and environmentally-friendly nematode control options. Many of such

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options have been and are still being investigated. Among these are;

- Use of resistant varieties;
- Use of Non-susceptible plants in rotations;
- Modification of the cropping system;
- Use of organic amendments;
- Use of physical factors, especially heat;
- Botanicals;
- Biological control.

Use of Resistant Varieties

By definition, resistant varieties are those that will not allow the PPN to multiply; or will do so at a very low rate. The reason for this may be constitutive (pre-infectional) or induced (post-infectional). Regardless of the mechanism of resistance, the end result is that growth and yield of resistant plants are not negatively affected in the presence of the nematode. For example, resistant rice (cv. LeMont) (Fademi & Fawole 1995) and soybean (TGM 1784) (Iheukwumere *et al.* 1995) did not support the development of *Meloidogyne incognita*. In potatoes, rate of penetration of resistant varieties by *Pratylenchus penetrans* was very low (Fawole 1999). Resistant varieties are particularly environmentally-friendly and do not require additional inputs or technology by the farmer. They, however, require the collaboration of plant breeders in their development.

Use of Non-susceptible Plants in Rotations

Several studies have been conducted to determine the efficacy of crop rotation sequences for the control of specific PPNs on particular crops. In such sequences, non-susceptible crops are rotated with susceptible crops. Since PPNs are obligate parasites, the dominant PPN in the field will die after a while in the absence of a susceptible crop. For example, Nwanguma and Fawole (1997) reported that a 3-year gap involving growing non-susceptible maize, amaranthus and groundnut in between susceptible okra successfully controlled *Meloidogyne incognita*.

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Cover crops can also be used in between seasons provided that the cover crop is not susceptible to the dominant PPN in the field. Claudius-Cole *et al.* (2001) reported that *Aeschynomene histrix, Centrosema pubescens, Crotalaria juncea* and *Tagetes erecta* could be useful as cover crops in the management of *Meloidogyne incognita.*

The major drawback in this method is finding a non-susceptible crop, and one with the same economic value as the susceptible crop, especially if the nematode has a wide host range. Farmers generally are not interested in investing time, energy or money in growing crops for which there will be no economic return.

Modification of the Cropping System

Damage by PPNs tends to be more severe under monocrop situations. This is because the availability of food from the susceptible crop allows the PPN to thrive. Consequently, it has been postulated that intercropping a non-susceptible crop with a susceptible one may confer some protective benefits on the latter. Idowu and Fawole (1989, 1992) investigated the efficacy of intercropping cereals (poor hosts) with cowpea (good host) in the control of the root-knot nematodes, *Meloidogyne* spp., as well as improving crop yield. The results were inconclusive and tended to suggest that intercropping could be used only if the poor host also possesses nematicidal attributes. Examples of such crops are *Tagetes* spp. or *Crotalaria* spp. which produce nematoxic and nematicidal root exudates.

Use of Organic Amendments

Organic matter (fruit peelings and cow dung) (16t/ha) suppressed root-knot nematode (RKN) population by 65% and increased okra yield by 30% (Nwanguma and Fawole 2004), especially when they were allowed to decompose for up to six weeks before application into the soil. It is postulated that the organic matter stimulates the population of parasites and predators of PPNs in the soil and these help to knock down their populations. In addition, the organic matter helps to improve soil characteristics and nutrition, to the advantage of the growing plant.

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Use of Physical Factors

Physical factors have been severally used in the management of PPNs. However, none has been as effective as the use of heat. Moist heat (as steam or hot water) has been used to disinfest planting materials or small quantities of soil. This method, especially hot water immersion, has been widely used in disinfesting yam tubers and other storage organs of PPNs (Fawole and Osunlola 1999). There is a temperature-time relationship that must be adhered to if the material being treated is to remain viable after treatment. The general rule is that the material is immersed in hot water at 50^0C for about 30 minutes. Immersing the material in the hot water eliminates about 95% of the nematodes in the treated material.

Use of Botanicals

Botanicals are plants whose extracts of various plant parts are used for pest control purposes. Several botanicals have been reported to be efficacious against PPNs. Onifade and Fawole (1996) evaluated aqueous extracts of the leaves of cashew (*Anacardium occidentale*), bitter leaf (*Vernonia amygdalina*), "efinrin" (*Ocimum gratissimum*) and gmelina (*Gmelina arborea*) on *Meloidogyne incognita* (Mi) and found that all the extracts suppressed populations of the nematode, and also increased cowpea yield. Fatoki and Fawole (1999) also evaluated extracts of the leaves and bark of neem (*Azadirachta indica*), leaves and roots of gliricidia (*Gliricidia sepium*) as well as leaves and roots of Siam weed (*Chromolaena odorata*) on Mi. All extracts inhibited Mi egg hatch and killed all second-stage juveniles of the nematode. In another study, Adekunle and Fawole (2003) assessed the use of Siam weed leaves and roots and neem leaves in the control of *Meloidogyne incognita* (Mi) on cowpea. Neem leaves reduced Mi population by 83.4% and increased grain yield by 107%, compared to the control plants. Siam leaves (50kg/ha) increased grain yield by 50% and Siam roots (50kg/ha) by 29%.

In an attempt to characterize the active components in the efficacious botanicals, Fatoki and Fawole (2000) reported the presence of tannins and amines (including methylamine) in neem leaves; alkaloids, flavonoids, amides and ketones

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(including benzylethanone) in Siam leaves; and alkaloids, saponins, falvonoids amides (including benzamide) and ketones (including benzylethanone and o-hydroxylbenzanone) in Siam weed roots.

While these botanicals show promise for use in nematode control, the major drawback in their use is the rate at which they are efficient. Very often, large quantities (50kg/ha) are required. Availability and the mode of incorporation of these large quantities may be a major factor against their widespread acceptance.

Biological Control

Biological control of PPNs is the use of other organisms to suppress nematode populations. There are many natural enemies of PPNs which have potentials for the biological control of the nematodes and these include fungi, bacteria, viruses, protozoa, other nematodes, etc. Of these, the fungi have received the most attention. Sadly, this aspect of nematology research has not received sufficient attention. Part of the problem stems from the fact that the known parasites/predators of PPNs do not have an obligate relationship with the nematode host/prey. The other problem is that of successful colonization and persistence of the introduced biocon agents in the soil. Consequently, applications have to be repeated severally and this makes the method difficult to use in fields.

In a recent study, Oyekanmi *et al.* (2008) reported that microorganisms such as *Trichoderma pseudokonigii, T. viride, Paecilomyces lilacinus, Glomus mossae* and *Pseudomonas fluorescens* reduced root-knot nematode population by up to 80% and improved maize growth by 46%. Certainly, a lot more can be done on the biological control of PPNs in Nigeria as Nigerian soils are known to be very rich in the natural enemies of PPNs.

Nematode Taxonomy, Systematics and Classification

Although I have not been active in this area of research, a few words would still be in order. Taxonomy, *sensu stricto*, is the theoretical study of classification (the ordering of organisms into groups) while systematics is the study of organisms and the

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relationships among them. In conducting studies in this area, one needs very good light microscopes, in addition to high resolution scanning and transmission electron microscopes. Other useful techniques for distinguishing specific differences include electrophoresis, chromatography, serology, DNA characterization and the use of monoclonal antibodies.

Studies in these areas are useful in nematode identification, in giving an insight into the direction of evolution of states of a character, as well as in solving practical taxonomic questions and proposing general nematological classification and identification schemes that are accurate and easy to use.

My inactivity in this area is not really by choice. The facilities are just not there; what with the "Mungo Park" light microscopes available at my disposal. There are other impediments. In the 1985/86 academic session, I spent a year at the Imperial College at Silwood Park, Ascot learning how to use electrophoretic techniques for nematology research. I came back with a lot of chemicals useful in electrophoretic research. If the truth be told, I am yet to run my first gel since my return from Imperial College over 20 years ago because I could not acquire an electrophoresis kit. Of course, the chemicals I brought with me have long expired and are no longer useful.

What Does It All Add Up To?

For the past three-quarters of an hour or thereabouts, I have taken you through the world of plant-parasitic nematodes (PPNs), very small animals with tremendous impact on our ability to be food self-sufficient. On their own, PPNs are very important. However, it must be appreciated that, on the field, the pest situation is polyspecific; in addition to the PPNs, there are also fungi, bacteria, viruses, insects, weeds and rodents. Therefore, a holistic approach to pest control becomes very important.

It is commonly acknowledged that agricultural growth spurs economic growth. To that extent, therefore, more than the present salutary attention needs to be paid to the agricultural sector. In addition to not changing agricultural policies with every change in administration, the Federal Government, as well as State and Local Governments, must invest more in the

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agricultural sector to promote economic growth and food security. Again, the investment must capture the entire production and post-production components in all areas of agriculture and not just pest control which has been the focus of this lecture.

However, and because I operate within the confines of the University of Ibadan, I have the following, very specific recommendations for this environment; especially since we are celebrating 60 years of Humanities, Science and Technology.

- Given the present conditions of epileptic power supply, lack of water and outdated, often nonfunctional equipment, it is going to be impossible to make a Nobel Laureate in the sciences from this environment. In these days of 'on-shore, off-shore;' I sincerely sympathize with my junior colleagues. Our crude methodologies are not acceptable by Editors of serious academic journals. We pride ourselves as being the best in the land; and may be we truly are. Yes, indeed, the University of Ibadan still towers highest. I do not intend to court the anger of many seated here today; but what else can the one-eyed in the land of the blind be if not King? We should stop measuring ourselves by local standards. We must transform from being one-eyed into a 20/20 visual acuity institution. If we truly want to be up there, we must compare ourselves with the likes of Cornell, Harvard, Yale, Oxford, Imperial College, etc. We would have truly arrived when the London Times Educational Supplement lists the University of Ibadan among the top 200 universities in the world.

- Towards the above, amongst others, facilities need to be considerably improved for teaching and research here in the university. It is a sad story that students in the Faculty of Agriculture and Forestry are still using the same "Mungo Park" microscopes that I used as an undergraduate student here almost 40 years ago. It is a major task, if not outrightly impossible, teaching phytonematology to a class of 250 – 300 students with

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only 30 half-dead microscopes. My department, the Crop Protection and Environmental Biology Department, used to have a closed-circuit television (CCTV) system with which one could, at least, show the students what they were supposed to look for under the microscope. That packed up years ago and is yet to be resuscitated. We also had a scanning electron microscope (SEM) in the department but that has since become a specimen for the museum. We moved to our present building in January, 1977; at which time three controlled-environment growth chambers were also ordered. Regrettably, they never got wired up and have since become homes for rodents and some other creepy creatures. I am hoping that some of these facilities will be brought back to life before I retire from the university.

- Mr. Vice-Chancellor, Sir, Distinguished Ladies and Gentlemen, we are all aware that information delivery is now more and more in the digital form. And most of it is available free online. To this extent, therefore, the university must have in place a strong internet linkage for the entire university campus. We are trying in this regard but we are not yet there. For example, the Ethernet line in my office has not worked for over a year and I also do not receive wireless signals from the office. So, every time I need to use the internet, I must leave my office and go somewhere else. Students have virtually taken over the ICT Centre. So, I often end up in the Staff Club, where a million stars in a green bottle usually disturb my concentration. This is very unsatisfactory. I am hoping that the day will soon come when 24/7 internet connectivity will be widely available for staff and students in the University of Ibadan from the comfort of their offices and hostels, respectively.

- I submit that tough decisions will have to be taken to get us to where we want to be. And it will require understanding from all stakeholders; staff, students,

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parents and government alike. For a start, the fees charged just have to be increased. If, as it is said, it costs about N500,000/annum to train an undergraduate, a 10 – 20 % cost recovery policy is certainly not out of place. Federal universities must be allowed to reasonably increase their fees over time so that they can reequip their laboratories and put in place infrastructure that will allow for cutting-edge research. The disparity between what is charged in Federal universities (N15,000) and in the private universities (N400,000.00) is just too wide.

- Office holders in the University of Ibadan must also be aggressive fund-raisers for the units they head rather than just be contented with the allure and spoils of office. They need to tap into the very rich base of alumni from their units. Putting my money where my mouth is, I raised over N1.26 million while I was Acting Head of the Department of Crop Protection and Environmental Biology in the year 2000 and the money raised was used to rehabilitate and/or purchase some badly-needed equipment in the department. In this regard, let me congratulate the Vice-Chancellor for the admirable way he has attracted grants for the physical and environmental development of the University of Ibadan. I also congratulate the Head of the Department of Geology for how he continues to raise substantial of funds for his department. That is as it should be for every office holder in this university.

Acknowledgements

I joined the University of Ibadan community as an undergraduate in September 1969 and I have been here ever since, except for the time I spent in Cornell University; and, of course, my sabbatical years in various institutions locally and outside the country. This is now the opportunity to publicly acknowledge all those that have positively touched my life before and since my arrival here in 1969. They are very many. Consequently, Mr. Vice-Chancellor, Sir, Distinguished Ladies

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and Gentlemen, I may spend a little longer than the 2 or 3 minutes usually dedicated to this section. I, therefore, crave your indulgence and patience while tackling this part of the Lecture. I thank you for your understanding.

I want to start by appreciating God. "It is not of him that wills, nor of him that runs, but of God that shows mercy" (Romans 9:16). I testify that I have seen the goodness of the Lord in the land of the living. Truly, God has been extremely merciful unto me. Unto Him is ascribed all glory, dominion, power and praise. Halleluiah!

Majority of previous inaugural lecturers usually leave the best for last. Mr. Vice-Chancellor, Sir, Distinguished Ladies and Gentlemen, allow me to start with the best. And so, I want to thank the wonderful family that God has blessed me with. First of all, my ***Jewel of Inestimable Value - Pipy Fawole***. Among mortals, she has been my first, my last, my everything these past 30-something years. Indeed, and to borrow a line from Celine Dion, she is the reason I wake up everyday. Thank you for being there for me.

God has also blessed us with four wonderfully-made children; Rotimi, Oluwaseun, Ekundayo and Babajide. Thank you guys, for also being there for me. The addition of Bisola and Ayokunle to the family has also been a tremendous blessing for us all.

I will also want to thank some members of ***The Saints Triumphant***, without whose efforts I will not be here today. First of all my parents, Late Reverend Samuel Ladipo Fawole and Late Mrs. Victoria Oyenike Fawole, for the discipline instilled so early in my life. Mum, was a Titan for the way she bravely soldered on, solely shouldering the responsibility of two people when she lost her partner so early. I hope that my siblings and I didn't let her down. I am also grateful to Late Frank Babatunde Fawole, my elder brother who severally denied himself just so that my siblings and I could be comfortably educated and housed. Sadly, death clutched him at a tender age of 28 years, long before he could see his dreams in us realized. May the souls of the dearly departed continue to rest in perfect peace. Amen.

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My brothers and sisters, Engineer Ayo Fawole, Professor (Mrs.) Remi Sonaiya, Barrister Bade Akingbade and Engineer Muyiwa Obasa and their families are also gratefully appreciated for the love and togetherness we have always shared and still continue to share.

When my father died in 1965, we had to move out of the premises of St. Luke's College, Molete, Ibadan where he had been teaching. We had nowhere to go. My mother's sister and late brother-in-law, Justice S. A. Ogunkeye and Mrs. C. G. Ogunkeye invited us to move into their house at Sanda Street, Molete; which we did (as if we had much choice, anyway!). So, we joined Sola, Dara, Tosin, Femi, Sade, Funso and Wole at Molete. It was, indeed, a full house and the three plus years we spent there were very wonderful years, for which I remain ever grateful.

I also want to express gratitude to the larger Aronke and Fawole Families. They were very supportive in extremely difficult times. I am grateful to my in-laws, the Dediares of Warri; and in particular, Mr. Sam (late) and Mrs Lebi Okudu, Mr. Tselogun (late) and Mrs. Rose Dediare, Mr. Fanny (late) and Mrs. Tosanbami Inza, and Brig. (Rtd.) Sunny and Mrs. Tsaigbe Tuoyo. I also appreciate Hon. Dr. Alaba and Mrs. Olamojiba Lad-Ojomo. They have equally been wonderful.

Mr. Vice-Chancellor, Sir, Distinguished Ladies and Gentlemen, I have been fortunate and extremely priviledged to have attended the very best educational institutions available here in Nigeria and beyond: Government College, Ibadan; University of Ibadan, Ibadan and Cornell University, Ithaca, N.Y., U.S.A. I also did a sabbatical stint at Imperial College at Silwood Park, Ascot, UK. All of them have had a telling influence on me and have helped to mould me into what I am today. I am grateful to all my teachers and supervisors for this. Some of my classmates from GCI and UI are here. They have all been a part of what I am today. I thank them most sincerely.

I am also grateful to all members of 'The Group'. The Group was a socio-philanthropic association with the enhancement of family values as its focus of activities. It was also an assemblage of focused, goal-oriented and upwardly-mobile young men. Members were mutually reinforcing and

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supportive as and when necessary. I thank the following, and by extension their wives and children, for being there when it mattered most: Segun Agagu, Olugbemi Akinkoye, Funso Onafowakan, Tony Marinho, Wole Ogunseyinde, Tunde Ikotun, Tunde Bamgbola, Tokunbo Abiose, Olu Agunloye, Tunde Osotimein, Lekan Oyejide, Dipo Otolorin, Laoye Jegede, Ofiafate Ofrey, Lani Sogbetun, Sunny Odunfa, Jimi Ashaye, Charlie Brimmo, Pat Alabi, Segun Ojosipe and Bola Awotedu. Looking back, I believe that we can shout EBENEZER. Truly, indeed, has the Lord been our Helper. To God be the glory.

In the last 32 years or so, I have been a staff in the Department of Agricultural Biology, now renamed the Department of Crop Protection and Environmental Biology. In the process, I have been fortunate to have supervised and still continue to supervise very many students at all levels; B. Sc., M. Sc., M. Phil. and Ph. D. I want to especially appreciate those that have completed their Ph. D. studies under my supervision: Professor Steven Afolami, Dean of Postgraduate School, University of Agriculture, Abeokuta; Dr. Emeka Nwauzor, Director and Sweet Potato Programme Leader, National Root Crops Research Institute, Umudike; Dr. Ademola Idowu, Executive Director, National Horticultural Research Institute, Ibadan; Dr. Tayo Fademi, Director, Cocoa Research Institute of Nigeria, Ibadan; Dr. Charles Ononuju, Senior Lecturer and Ag. Head, Department of Crop Protection, Michael Okpara University of Agriculture, Umudike; Dr. Ephraim Nwanguma, Assistant Director, National Horticultural Research Institute, Ibadan; Dr. Kola Adekunle, Reader and Ag. Head, Department of Plant Sciences, Obafemi Awolowo University, Ile-Ife; and Dr. Abiodun Claudius-Cole, Lecturer, Department of Crop Protection and Environmental Biology, University of Ibadan, Ibadan. Mr. Vice-Chancellor, Sir, Distinguished Ladies and Gentlemen, these are my beloved children in whom I am well-pleased. Whatever success I may be enjoying today belongs to them all as well.

I also deeply appreciate all my colleagues in the Department of Crop Protection and Environmental Biology, as well as those in the Faculty of Agriculture and Forestry and in the university community at large.

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I have had a productive association with two scientists at the International Institute of Tropical Agriculture, Ibadan; Dr. R. Asiedu and Dr. Danny Coyne. I thank them most sincerely for allowing some of my postgraduate students to use their facilities.

I also want to express my sincere gratitude to Professor Johnson Ekpere, former Executive Secretary, Scientific, Technical and Research and Commission (STRC) of the African Union. Professor Ekpere was the person that introduced me to the international community when he nominated me to serve as Nigeria's representative on the Executive Council of the InterAfrican Phytosanitary Council (IAPSC) of the African Union. And since the international community thrives on the referral system, particularly if you deliver, one assignment has led to another, and to another, and to another, etc.

I thank my brother, my friend, my "*oga*", Professor Rotimi Tayo for his interest in my progress. I am equally grateful to my friends and colleagues in Hope Society, St. Peter's Cathedral, Aremo, Ibadan; my friends and colleagues in The Resurrection Morning Star Society, Chapel of The Resurrection, University of Ibadan; my friends and colleagues at "abe-igi" (Spina), Oando Petrol Station, Mokola, Ibadan; my friends and colleagues at the Ibadan Recreation Club; and my very good friend and colleagues at The Crescent, Akobo.

Mr. Vice-Chancellor, Sir, Distinguished Ladies and Gentlemen, lately, it has not been all about phytonematology. On account of my association with ITOCA – the Information, Training and Outreach Centre for Africa (*www.itoca.org)* based in Centurion, South Africa, I have become very involved in the application of ICT for teaching and research in tertiary educational institutions and national agricultural research institutes (NARIs) all over Africa. Under the auspices of ITOCA, the past four years or so have seen me training University and NARIs staff in the effective use of HINARI (Health Internetwork Access to Research Initiatives) (*www.who.int/hinari*), AGORA (Access to Global Online Research in Agriculture) (*www.aginternetwork.org*), OARE (Online Access to Research in the Environment) (*www.oaresciences.org*) and TEEAL (The Essential Electronic

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Agricultural Library) (*www.teeal.org*). HINARI, AGORA and OARE are online electronic databases that, collectively, provide FREE access to over 7000 up-to-date journals in the areas of health, agriculture and environment, respectively. TEEAL is an offline e-database of about 135 agricultural journals. Any serious teacher, researcher or student in these disciplines must be constantly using these databases. But the discussion on HINARI, AGORA, OARE and TEEAL is a lecture topic for another day.

On account of my association with ITOCA, I acquired one of the best private collections of agricultural literature in the world. Early in October 2008, I donated this collection; a 300G LanTEEAL hard drive and update CDs containing digitized images of 115 core agricultural journals for the years 1993 – 2005 and some other CDs, to the Kenneth Dike Library as part of my own contributions to the UI @ 60 celebrations. The association has also taken me to all but a few countries in Africa, for which I am very grateful. In addition, I was able to fully practise my hobby of numismatism. A numismatist is someone who collects coins and bank notes. I now have a very rich collection, even if I have to say so myself, including a 50 billion Zimbabwean dollar note. I am discussing with Dr. Pogoson, the Curator at the Institute of African Studies to see if we can have an exhibition of the coins and notes in the near future.

Conclusion

Mr. Vice-Chancellor, Sir, Distinguished Ladies and Gentlemen, I started this inaugural lecture with a true story. Let me also end it with another true story. It was in January 1972, again, almost to the date, that the then Head of the Department of Agricultural Biology called me to his office. I was a final year student in the department then. He asked me whether or not I was considering postgraduate studies after graduation. I answered in the negative, that I would immediately look for a job after graduation and start earning some money so I could help ease the strain on my mother who was struggling hard to see my siblings and I through school. I told him that my father had died since 1965 and it was only my mother who was there for us; and

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that there was no way I would ask her to fund my postgraduate studies when I still had juniors in secondary school and university. He smiled and just passed me a form to go and fill. It turned out to be an application form for admission into postgraduate studies at Cornell University, Ithaca, N.Y., USA.

For more than four weeks, I refused to fill the Form. As I told my classmates then, "*kini wahala HOD yi? Ta lo so pe on fe lo fun postgraduate studies?*" The HOD also did not say anything until one day after lectures, when he asked me to see him in his office. I confess that I was shaking very badly while going to his office because I knew what was coming. He asked for the form he gave me and I told him I hadn't yet filled it. He didn't say anything other than "OK, you can go". I left his office, rode furiously on my bicycle to my room in Independence Hall, filled the form and brought it back to him, all in less than 20 minutes. He didn't take the form from me. He just asked me to drop it on his table, which I did. When I related the story to my classmates, I concluded by saying "*kini wahala? Mi o kuku so pe mo fe se postgraduate studies tele*".

After our final examinations in June and while still waiting for the results, I was again called by the HOD, to his office. When I got there, he passed a sheet of paper to me. It was the letter of admission into postgraduate studies in the Department of Plant Pathology at Cornell University. I was stunned and totally speechless. Bemused at my confused state, he passed me another letter. It was a Letter offering me a University of Ibadan/Ford Foundation Staff Development Fellowship. I immediately prostrated fully in appreciation. He simply smiled and just said "continue to do well". The rest, like they say, is history.

Who was this benevolent HOD? Mr. Vice-Chancellor, Distinguished Ladies and Gentlemen, I have been talking about another member of The Saints Triumphant, Late Professor Theophilus Ajibola Taylor. Professor Taylor was ***A Man of Excellence*** and he inculcated in all of us that passed through him that desire to always pursue excellence in all we do. And that has been my guiding principle ever since. The good he did has not, and will never, be buried with him. I am sincerely grateful to him for seeing in me what I did not readily see in

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myself, and for being totally detribalized in his own pursuit of excellence. The laudable ideals that he implanted in me and some others he mentored live on in us, and in those whom we also try to mentor. May His soul continue to rest in perfect peace. Amen.

Finally, Mr. Vice-Chancellor, Sir, Distinguished Ladies and Gentlemen, this is the Great University of Ibadan, the Nation's first, and still the best, university. We all are joint stakeholders in the University of Ibadan (UI) Project and we have an obligation to see that it grows from strength to strength, and from glory to glory. The third stanza of the GCI School Song goes as follows:

Generations shall come and go
But our pride you will for aye remain
May be not in the confines of your walls
But in Alumni world-renowned
School of our pride we build on thee.

Certainly, the University of Ibadan is not the same as Government College, Ibadan. But the words are as applicable to UI as they are to GCI. Are we building on the University of our pride?

As we collectively take our beloved UI to the next 60 years, I leave you all, staff and students alike, with the words of John Wesley (undated)

Do All the Good you can
By All the Means you can
In All the ways you can
At All the Times you can
To Everyone you can
As long as you ever can
Do All the Good you can.

Thank you very much and God bless us all.

UNIVERSITY OF IBADAN LIBRARY

Literature Cited

Adekunle, O.K. and B. Fawole. (2003) Chemical and non-chemical control of *Meloidogyne incognita* infecting cowpea under field conditions. *Moor J of Agric. Research.* **4**(1):94 -99.

Afolami, S. O. and B. Fawole (1991) Effect of *Pratylenchus sefaensis* Fortuner, 1973 on growth and yield of *Zea mays* L. cv. FARZ-7 under continuous cropping. *Plant and Soil* **138:**133 – 138.

Caveness, F. E. (1965) End of tour progress report on the Nematology Project 620-11-110-050. Ibadan. Ministry of Agric. & Natural Resources. Western Region, Nigeria and United States Agency for International Development, Lagos, Nigeria. 135pp.

Claudius-Cole, A. O., B. Fawole and R. Asiedu (2001) The role of cover crops in the management of *Meloidogyne incognita* and other plant-parasitic nematodes. Afri. Crop. Sc. Proceedings. **5**:265 – 269.

Fademi, O.A. and B. Fawole (1995) Effect of rice resistance on infection by *Meloidogyne incognita. Nematropica* **25**(2):177 – 180.

Fatoki, O.K. and B. Fawole (1999) *In vitro* toxicity of some selected plant extracts on eggs and second-stage juveniles of *Meloidogyne incognita. Afr. J. Plt. Prot.* **9:**83 – 92.

Fatoki, O.K. and B. Fawole (2000) Identification of nematicidal ingredients from neem leaves, Siam weed leaves and roots. *African J. Pl. Prot.* **10:**33 – 38.

Fawole, B. (1972) The role of weeds in carrying over inoculum of the reniform nematode, *Rotylenchulus reniformis* over the dry season in southwestern Nigeria. B. Sc. (Agric.) Undergraduate Student Project, Department of Agricultural Biology, University of Ibadan. 33pp.

_____(1988) Histopathology of root-knot nematodes, *Meloidogyne incognita* infection on white yam, *Dioscorea rotundata* tubers. *J. Nematol.* **29**(1):23 – 28.

_____ (1999) Expression of resistance in potatoes (*Solanum tuberosum*) to *Pratylenchus penetrans. Global J. Pure & Appl. Sc.* **5**(4): 479 – 484.

Fawole, B, and O. A. Awogboro (1990) False Alarm! No potato cyst nematode in Nigeria yet. *Int. Nematol. Newsletter* **7**(2): 35 – 37.

UNIVERSITY OF IBADAN LIBRARY

Fawole, B. and A. A. F. Evans (1989) Respiratory changes in yam storage tissue infected by *Meloidogyne incognita* using a novel technique for measuring oxygen uptake. *Ann. Appl. Biol.* 141 – 145.

Fawole, B. and A. O. Claudius-Cole (2000) Plant-parasitic nematodes as constraints in the production of potatoes and sweet potatoes in Nigeria. *African Potato Ass. Conf. Proceedings.* **5**: 421 – 424.

Fawole, B. and A. A. Fajemisin (1988) Influence of *Meloidogyne incognita* on root-knot nematode-resistant and susceptible soybean cultivars. Tests of Agro-Chemicals and Cultivars No. 9 (*Annals of Applied Biology*, **112**, Supplement): 94-95.

Fawole, B. and W. F. Mai (1977) Influence of Plant Age, Light Intensity, Nematode Inoculum Level, and their interactions on tomato growth and reproduction of *Meloidogyne hapla. J. Nematol.* **11** (2): 199 – 201.

Fawole, B. and W. F. Mai (1988) Pathogenicity and reproduction of *Pratylenchus penetrans* on Wando peas as influenced by plant age at inoculation, light intensity, nematode density, and their interactions. *Fitopatol Bras.* **13**(4): 348 – 350.

Fawole, B. and M. A. Raji (1988) Relationships between number of *Heterodera sacchari* cysts and upland rice growth and development. *Tests of Agrochemicals and Cultivars.* No. 9 (*Ann. Appl. Biol.* 112, Supplement): 108 -109.

Fawole, B. and O. S. Osunlola (1999) Comparative efficacy of thermotherapy and chemotherapy in the control of root-knot nematodes, *Meloidogyne* spp. infecting yam tubers. *Afr. J. Root and Tuber Crops* **3**(2), 38 – 40.

Idowu, A.A. and B. Fawole (1989) *Meloidogyne* species in mixed cropping systems in the rainforest and savannah zones of Nigeria. *Pak. J. nematol.* **7**(2): 103 – 108.

_____ (1992) Effect of intercropping maize with cowpea on the pathogenocity of *Meloidogyne* spp. *Nig. J. Plt Prot.* **14:** 70 – 74.

Iheukwumere, C.C., G. I. Atiri, B. Fawole and K. Dashiel (1995) Evaluation of some commonly grown soybean cultivars for resistance to the root-knot nematode and soybean mosaic virus in Nigeria. *Fitopatol. Bras.* **20**(2): 190 – 193.

UNIVERSITY OF IBADAN LIBRARY

Iheukwumere, C.C., G. I. Atiri, B. Fawole and K. Dashiel (1996) Interaction between soybean mosaic potyvirus and *Meloidogyne incognita* infection. *Afr. Crop Science Journal.* **4**(3): 351 – 357.

Nwanguma, E. I. and B. Fawole (1996). Water relations and growth of *Meloidogyne incognita*-infested tomatoes. *Afr. J. Plt. Prot. 6, 119 – 124.*

_____ (1997). Crop rotation sequences for the control of *Meloidogyne incognita* on okra in south-western Nigeria. *African J. Pl. Prot.* 7, 161 – 166.

_____ (2001). Effect of seedling age on disease severity and early growth of Meloidogyne incognita-infested okra. *African Crop Sc. Proc* 5, 271 – 275.

_____ (2004). Determination of appropriate decomposition period of two organic materials for effective control of root-knot nematodes on okra. *Moor J. of Agric. Res.* 5(1), 19 – 25.

Nwauzor, E. C. and B. Fawole (1990). Penetration and survival of root-knot nematodes (*Meloidogyne incognita*) in stored yam (*Dioscorea rotundata*) tubers. *Nig. J. Plt Prot.* 13, 60 – 65.

_____ (1992). Development and life cycle of *Meloidogyne incognita* (race 2) in *Dioscorea rotundata* var. Okwocha. Pp. 127 – 133 In The Biology and Control of Nematode Pests of Food Crops in Africa. B. Fawole, O.A. Egunjobi, S. O. Adesiyan, J. O. Babatola and A.A. Idowu (Eds.) HisWill InfoResources Management Limited, Ibadan.

Onifade, A. K. and B. Fawole (1996) Effect of some plant extracts on the pathogenicity of *Meloidogyne incognita* on cowpea. *Global J. pure & App. Sc.* **2**(1), 9 – 15.

Ononuju, C. C. and B. Fawole (1997). Population dynamics of plant-parasitic nematodes on plantain cv. Agbagba. *Afr. J. Plt. Prot.* **7**, 151 – 160.

_____ (1999) Pathogenicity of *Meloidogyne* sp. on banana cultivars. *Niger. J. Plt. Prot.* **18**: 21 – 28.

UNIVERSITY OF IBADAN LIBRARY

_____ (2000) Evaluation of ethoprophos, isazophos, carbofuran and nemagon for the control of plant-parasitic nematodes and their effects on plantain growth and yield. *Nig J. Science* **34**(1), 81 89.

Onwuliri, C. O., E. B. Alo and F. Enwemaya (1988) Ecological studies on nematode pests of agricultural farms in Plateau State (Abstr. A11). Pp. 13 In Book of Abstracts. 1st National Workshop on the Control of pests and Disease Vectors in Nigeria. University of Jos; February 21 – 24, 1988.

Oyekanmi, E.O., D.L. Coyne and B. Fawole. (2008) Utilization of the potentials of selected microorganisms as biocontrol and biofertilizer for enhanced crop improvement. *J. Biological Sciences* **8**(4): 746 – 752.

UNIVERSITY OF IBADAN LIBRARY