FEDERAL UNIVERSITY OF AGRICULTURE
ABEOKUTA NIGERIA

71st INAUGURAL LECTURE

TENDING THE INAUDIBLE: THE MANAGEMENT OF PLANT AFFLICTIONS WITH THE ENDOWMENTS OF NATURE

by

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FUNAAB INAUGURAL LECTURE SERIES

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All Special Guests and Friends of the University,
Members of my Family and Friends,
Distinguished Fellows and members of the Nigerian Society for Plant Protection;
Gentlemen of the Press,
Ladies and Gentlemen,
Great FUNAABITES

1.0 PROEM

With a humble heart and deep sense of gratitude to God, I stand before you all to present an Inaugural lecture titled "Tending the inaudible: The management of plant afflictions with the endowments of nature"

This Inaugural Lecture is made possible by the tradition of the University to request Professors to present the summary of their academic pursuits in a forum like this.

I therefore, thank the immediate past Vice Chancellor and Chairman of Senate for approving my nomination to present this lecture which is the first in the Department of Crop Protection, 14th in the College of Plant Science and Crop Production and 71st in the Federal University of Agriculture, Abeokuta.

2.0 INTRODUCTION

One of the life features that plants and animals share in common is the concept of disease – a situation where influences beyond the control of a body compel the entity to operate below its optimal potential. In such situations, body functions are held down and overrun by the external agent that tends to violate the integrity of the body system by forcing its (external agents) preference on the body. In both man and plants, a disease is an aberration that redefines the very essence of the man or plant. However unlike man, a diseased plant;

- Is not audible – either they do not cry or when they do, we do not hear.
- Cannot relocate away from the point of threat or move around to seek help, as men and animals would do.

These peculiarities are the reasons that make diseases of plants issues of concern and the basis for this Inaugural Lecture which is the account of my stewardship in being a 'Plant Doctor'.

In technical terms, a disease is an abnormal physiological condition induced by a primary causal factor and reflected in characteristic expressions called symptoms. According to Agrios

(2005), diseases in plants are the series of invisible and visible responses of plant cells and tissues to pathogenic organisms or environmental factors that result in adverse changes in the form, function or integrity of the plant, and may lead to partial impairment or death of plant parts or the whole plant. From this definition, a disease condition in plants:

- involves external agent of disease which could be living or non-living,
- imposes adverse influences and outcomes on the host plant physiology,
- elicits responses (visible or invisible) from the host plant,
- compromises or forcefully changes the form, shape and/or integrity (value) of the plant,
- and may lead to death of the plant or plant part, if allowed to run its full course.

2.1 Pathogens as Biotic Agents of Disease

Living (biotic) things that cause diseases in plants are called Plant Pathogens while Plant Pathology is the study of plant diseases. There are several forms of Plant Pathogens namely – fungi (which is the main emphasis in this discourse), bacteria, viruses, nematodes, mycoplasma, phytoplasma, viroids, etc. These agents are in themselves living entities that seek to exist by finding habitation on and/or in plants. They are adapted to living on these host plants sometimes entirely, in which case, without the host plants they, may not live a full life. This fact had raised a puzzle among fresh students of Plant Pathology who were divided in their views as to whether or not it is fair to 'chastise' disease agents as pathogens since they were 'created' to find sustenance on another living entity, just as man feeds on chicken to make merry at Christmas!

2.1.1 *Fungi as Plant Pathogens*

A fungus is a plant with a distinction. Fungi are made up of

eukaryotic (nuclei membrane - bound) cells that contain cell wall made of chitin and glucan (and not cellulose). The body structure (thallus) is mostly multicellular (except yeast) and adapted into a threadlike (tubular sequence) called Hyphae. Fungi are non-chlorophyllous (i. e. they do not contain chlorophyll) and therefore heterotrophs (i. e. they obtain required nutrients from other organisms). They digest food externally with the aid of hydrolytic enzymes and absorb nutrients directly through the cell walls. Fungi therefore obtain carbon and energy from other organisms and store the carbohydrate produced in form of glycogen. The heterotrophic nature of the fungi is the basis of being causal agents of plant diseases, and thus a subject of interest of Plant Pathologists.

Some fungi obtain nutrients directly and sorely from a living host plant (in which case they are called 'biotrophs' or 'obligates'), while some infect living plants and obtain nutrients from infected (dead) host cells (Necrotrophs). Others obtain nutrients only from dead plants or plant parts not killed by them (Saprophytes). It is therefore noticeable that fungal plant pathogens are either biotrophs or necrotrophs. For these groups of fungi, survival has become centred on the host plant without which their life cycles will not be complete.

Fungal plant pathogens reproduce asexually by the production of large number of asexual structures such as spores, conidia, sclerotia, chlamydospores, etc. These structures vary in shape, size, coat hardness, resistance to adverse conditions, adaptability for dispersal and ability to survive over generation of crops. In some situations, fungal pathogens reproduce sexually and in this instance, it may be by fusion of cytoplasm (plasmogamy), or fusion of nuclei (gametes) (kargogamy). The different types of some fungal pathogens of tropical crops and their adaptive and reproductive structures are presented in Table 1.

Table 1: Reproductive and adaptive structures of some Fungal pathogens of selected tropical crops

Fungal Pathogen	Disease/Crop Infected	Reproductive Structures and Characteristics
Sclerotium rolfsii *Rhizoctonia solani*	Damping-off of seedlings, stem canker, root, crown, bulb and tuber rot of annuals and biennials	Sclerotia, mycelia (hardy, adverse weather resistant propagule) *R. solani* produces rhizomorphs
Fusarium species	Fusarium wilt of annuals and perennials, head blight of cereals, grain mould, bulb rots.	Production of large number of multicelled conidia and capacity to withstand adverse weather conditions, over-winter in stables over time.
Colletotrichum species	Anthracnose disease of annuals (cereals, grasses), perennials (mango, cassava, pawpaw, yam), etc.	Fungus overwinter as mycelium, perithecia or conidia in rotten fruit, seed and or plant debris.
Curvularia, Helminthosporium, Alternarnia, Septoria species	Leaf spot and blight of foliage, stem and fruits of crops, seed infection and discoloration.	Production of large number of air-borne multicelled conidia and over-winter through hyphal fragments on crop residue and seed.
Penicillium, Aspergillus, Rhizopus species	Mould of fruits, tuber and fruit rots, seed infection and discolouration.	Production of large number of air-borne spores/conidia. Survival through hyphal fragments on seeds and crop residues.
Choanephora curcubitarium	Rot of flowers, fleshy fruits/vegetables.	Production of air-borne spores from profuse mycelia mass.
Puccinia species	Rust of cereals, sugarcane and legumes.	Production of large number of uredospores and overwintering on an alternate host (Barberry plants)

Source: Mehrothra and Aggarwal (2004); Agrios (2005)

2.2 Forms of Losses Induced by Fungal Plant Pathogens

There is the dearth of accurate data on the quantitative estimate of losses due to fungal diseases of crops in Nigeria. However, plant pathogens account for between 16 and 18% global crop loss as plant pathogens rank next to weeds as the major cause of potential loss of attainable yield in crops (Oerke, 2006). Aside the negative impact on crop yield, plant diseases also affect the overall value (utilisation) of farm produce and products (Savary, 2012). Crop losses resulting from the adverse effect of fungal diseases are also noticed through:

i) Direct crop losses on the field as a result of failure of diseased crops to give optimal yield.

ii) Some diseases which can induce up to 100% crop loss as in wilt diseases of tomato, cowpea and Sclerotium rot. Others may not kill the entire plant, but reduce the capacity of the plants to give valuable yields. Such is seen in cases of the Banana sigatoga, Cowpea blight, Rice blast, Sesame leaf spot and blight among others.

iii) Losses which can also occur as a result of increased cost of management of diseases in the field and in store. Deployment of disease control efforts amount to an overall increase in the cost of production thereby reducing the profit accruable from crop production.

iv) Direct losses as a result of storage disease also reduce overall value of stored products. This includes reduced quality and value of stored products arising from mouldy grains, discoloured seeds and mycoflora infection of stored seeds/ grains. Tuber rots of yam and potatoes also reduce the value of erstwhile healthy produce in storage.

v) Losses due to failure of stored produce to become viable seeds or propagation units in the new season is also commonplace. By this, additional cost is incurred in procuring new seeds/grains and propagating units.

vi) Human and animal health hazards arising from adverse

effect of mycotoxins produced on seeds by fungi on the field and store. Man and livestock are adversely affected by the consumption of food products (mouldy grains, bread, hay, fruits) contaminated by mycotoxigenic fungal species. This attendant health consequence, mortality and cost of treatment is of global significance.

3.0 HOW DO PLANTS GET DISEASED?

Diseases caused by biotic agents such as fungi only occur when three critical factors align in harmony! The three factors are: Pathogen, Environment and the Host plant. For a disease to occur, the ability of the pathogen to induce infection on a host must be accentuated by an enabling environment. This means that a disease can occur only because all three components interact harmoniously without a limitation that is significant enough to forestall disease development. This concept is depicted by the Disease Triangle in Figure 1:

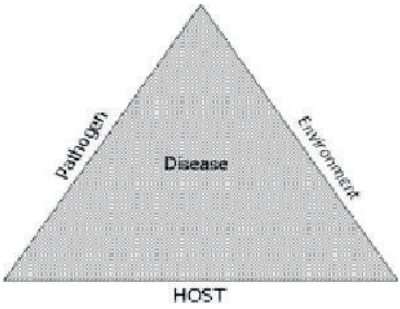

Figure 1: The Disease Triangle

Each side of the triangle represents one of the three components, and the disease produced is illustrated by the area of the triangle. It thus mean that the volume of the disease (represented by the area of the triangle) is determined by the extent or nature of relationship between the sides of the triangle (the components: Pathogen, Host

and Environment). Each component consists of different factors which determine the presentation of each component. These include:

(a)	Factors of the host plant	- Genetic make-up (susceptibility, tolerance, resistance) - Plant characteristics (age, physiology, morphology, anatomy, adaptive features etc)
(b)	Factors of the pathogen	- Pathogenic potential (virulence) - Inoculum features (potential), adaptations for infection, dispersal, survival. - Pathogen density, host preference and specificity etc
(c)	Factors of the environment	- Climatic factors (temperature, moisture, humidity, media pH, light, wind, soil factors, etc) - Biotic factors outside the host (man, animals, other macro and micro -organisms such as vectors, antagonists, symbionts, etc.)

The fact that the three components are required to produce a disease condition has provided a leeway for Plant Pathologists to exploit, in the attempts to manage plant diseases. Plant disease management options usually attempt to obstruct the synergy among these components in order to forestall disease development. Indeed, viable disease management options must be premised on the understanding of this relationship at any point in time, and then leverage on the knowledge to proffer a step that obstructs the harmony among the components and thus forestall or slow down disease development.

3.1 How do Fungal Pathogens induce disease in Plants?

The battle of wits among the pathogen (which seeks to earn a living!), the host (which desires to live an unhindered life!) and an environment that is neither a friend nor foe to either party is a complex but interesting scenario. “War arsenals" and “defensive bunkers” are developed and deployed by the pathogen and host

respectively at the cellular and molecular levels, the outcome of which has found a job and livelihood for Plant Pathologists.
Fungal pathogens infect host plants using different adaptive 'technologies' which include:

3.1.1 Mechanical weapons of war (Mechanical penetration of host surfaces)

Some fungi penetrate intact plant surfaces by exerting mechanical pressure to the plant surface. Much like the way a bandit forces his/her way into a fortified property. Usually when a spore lands on the plant/leaf surface, contact is ensured by adhesion. This is achieved through the production of mucilaginous substance that help fasten the spore to the leaf surface. Thereafter, the spore hydrates by absorbing available moisture on the leaf surface and produce a germ tube with which it grows on the leaf surface. The top of the germ tube becomes modified into bulbous and dense structure called appresorium. The appresorium produces a penetration peg at the basal end with which it breaks through the leaf cuticle and cell wall. After breaking through the host barrier (cell wall/leaf cuticle), an infection or penetration tube ramifies through the intercellular spaces and individual cells are broken into and the contents absorbed into the fungal pathogen with the aid of a specialised structure called Haustoria. This mechanism of infection is common with *Alternaria*, *Cochliobolus*, *Colletotrichum*, *Gaeumanomyces*, *Magnaporthe* and *Verticillium* species among others. Sometimes, the germ tube grows towards natural openings such as stomata and lenticels through which the appresorium injects the infection/penetration tube.

3.1.2 Chemical weapons of war (Chemical penetration of host surfaces by fungal pathogens)

Some fungal pathogens produce chemical compounds that aid the process of infection and invasion of host cells. The chemical compounds vary widely in their composition and mode of action. They include enzymes, toxins, growth regulators and

polysaccharides (Agrios, 2005). Enzymes and toxins are of more common importance in the pathogenicity on tropical plant diseases.

The typical plant cell wall is made up of protective 'shields' like cutin, wax, cellulose, pectin, hemicelluloses (Figure 2)

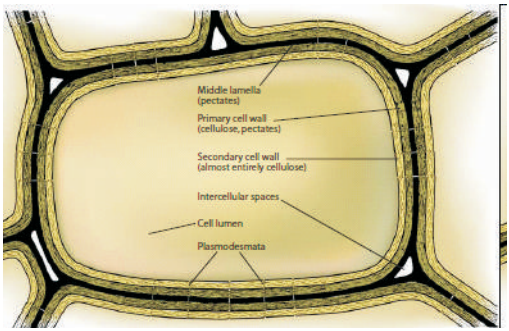

Figure 2: Schematic representation of the structure and composition of the plant cell wall

Source: Agrios (2005)

In order to successfully break through these barriers, fungal pathogens develop corresponding chemical "antidotes" with specific potential to degrade each of these components of the plant cell wall. Some of these chemical substances, produced by fungal pathogens as facilitators of pathogenicity are presented in Table 2.

Table 2: Some chemical substances used by fungal pathogens to invade their hosts

Chemical Substance	Producer	Pathogenic importance/ Characteristic
a) Enzymes Cutinases	*Monilinia fructicola* (Brown rot of stone fruits) *Botrytis cinerea*	Break cutin to polyester of C_{16} and C_{18} hydroxy fatty acid into small molecules
Pectinases / pectolytic enzymes (pectin methyl esterase, polygalacturonase, pectin lyase)	*Colletotrichum* species, *Rhizopus* spp., *Fusarium* spp, *Botrytes* spp., *Mucor* spp, *Monilia* spp.	Break down pectic substances (the major content of the middle lamella) thereby weakening cellular integrity and dissolving the intercellular cement that holds cells together. This leads to softening of infected tissue.
Cellulases (Xylanase, galactinase, arabinase, glucanase)	*Fusarium* sp, *Phellinus* sp., *Aspergillus* sp, *Trichoderma* sp., *Mucor* sp., *Formitopsis* spp., *Penicillium* spp, *Sclerotium rolfsii*.	Break down cellulose and hemicelluloses leading to softening and disintegration of cell wall materials.
b) Toxins Tentoxin	*Alternaria alternata*	It inhibits light-dependent phosphorilation of ADP to ATP and also interferes with the process of energy transfer to the chloroplast.
Cercosporin	*Cercospora* spp.	It is actuated by light which when absorbed makes it toxic to the plant through the production of activated oxygen
Hv-toxin or Victorin	*Cochliobolus (Helminthosporium) victoriae*	Causes blight and death only for a particular variety (Victoria) of Oat.
HC Toxin	*Cochliobolus (Helminthosporium Carbonum* Race/ *Biopolaris zeicola)*	Causes northern leaf blight and ear rot of a specific maize line by suppression of defence responses in the susceptible lines.

Source: Mehrothra and Aggarwal (2004); Agrios (2005

4.0 HOW DO PLANTS DEFEND THEMSELVES AGAINST FUNGAL PATHOGENS?

Plants defend themselves against fungal pathogens in a variety of ways that can be classified under two major categories namely:

(a) Structural defence mechanisms
(b) Biochemical defence mechanisms

4.1 Structural Defence Mechanisms of Plants

These are modifications in the morphology or structural features of the plant that limit penetration of host cells by the pathogen or invasion of host cells after the pathogen has successfully gained entry into the host tissue. These include:

- Formation of cuticle (a non-cellular membranous layer) on epidermal surfaces of leaves, and waxes which act as water repellent that prevents water retention on host plant surfaces.
- Thickening of epidermal cell wall through deposition of fortifying substances like lignin, silicic acid and cellulose.
- Modification and alteration of the structure of natural openings to forestall fungal pathogen access.
- Production of cork layers, tyloses and abscission layers, deposition of gums, resins, swelling of cells and sheathing of hyphae to discourage fungal invasion of host cells after entry into host tissue. Cork layers are dead cells produced as barrier between diseased and healthy host cells (Figure 3) while abscission layer is a gap created to prevent movement of pathogen from diseased to healthy cells of the host plant (Figure 4).

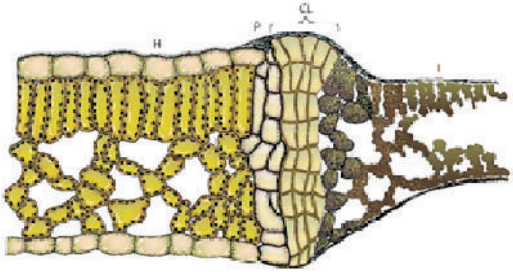

Fig 3:Formation of a Cork layer (CL) between infected (I) and healthy (H) areas of leaf
Source: Agrios (2005)

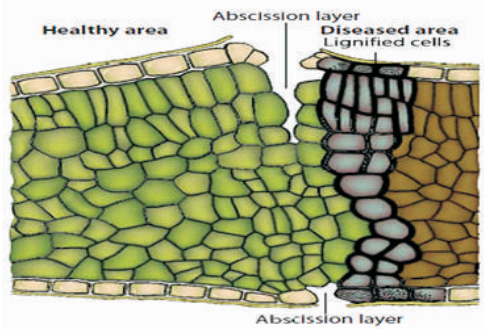

Fig 4: Formation of an abscission layer around a diseased spot of a leaf
Source: Agrios (2005)

4.2 Biochemical Defence Mechanisms of Plants

Biochemical substances used by plants to deter infection by fungal pathogens involve pre-existing chemicals already present before infection as well as those formed in response to infection. In both cases, the chemical substances serve to either inactivate or neutralise the effect of the invading pathogen or kill the pathogen outright. There are as many varieties of biochemical substances as there are varieties of plant pathogens and host plants. Some of the biochemical substances involved in plant defence mechanisms are presented in Table 3.

Table 3 : Some biochemical substances produced by plants as defence against fungal pathogens

Biochemical substance	Characteristics/Importance	Reference
Pathogenesis-related(PR) Proteins:		
•Peroxidases	Produced to limit cellular spreading of infection through establishment of structural barriers (e.g. lignin and suberin) or generation of highly toxic environments by massively producing reactive oxygen species.	Passard *et. al*., 2005; Prasannath, 2017
•β-1,3-glucanses	Achieves decomposition of glucans which is the major component of the cell wall of Oomycetes, a group of fungi that do not contain chitin. It also promotes the release of cell wall derived materials that can act as elicitors of defense reactions. Are active against *Aspergillus parasiticus, A. flavus, Blumeria graminis*, *Colletotrichum lagenarium*, *Fusarium culmorum, F. oxysporum, F. udum, Macrophomina phaseolina* and *Treptomyces sioyaensis*.	Wessels and Sietona, 1981; Bowles, 1990; Prasannath, 2017.
•Chitinases	Degrades Chitin which is the component of cell wall of most fungi. This leads to weakened and osmotic sensitive fungal cell walls. Chitinase and β-1,3-glucanses also act in synergy to inhibit fungi growth in host plants. Chitinases are involved in the control of *Alternaria* spp., *Rhizoctonia solani*, *Bipolaris oryzae*, *Botrytis cinerea*, *Curvularia lunata*, *Fusarium oxysporum*, *F. udum*, *Mycosphaerella arachidicola* and *Pestalotia theae*.	Jach *et al.*, 1995; Jalil *et al.,* 2015; Prasannath 2017; Manish *et al.*, 2018.
•Phenylalanine ammonia lyase (PAL)	*Involved in the formation of structural and biochemical defense materials such as lignin, suberin and phytoalexins. PAL activity is incited by pathogen invasion, wounding or any abiotic stress factors.	Prasannath, 2017
•Polyphenol oxidase (PPO)	Are groups of copper containing enzymes that catalyse oxidation of hydroxyl phenols to their quinone derivatives which are toxic to pathogens and plant cells. Increased PPO in infected plant cells have been associated with resistance to plant pathogens. PPO activity have been linked to production of antimicrobials in plant cells, acceleration of plant cell death, alkylation and reduced availability of cellular proteins to the pathogen as well as formation of physical barriers to pathogen movement within host plants.	Chunhua *et al.*, 2001; Prasannath, 2017.
Secondary Metabolites:		
-Terpenoids, Phenolics, inhibitors and Alkaloids	These are chemical substances preformed in plants for defence against Pathogens. They are usually not involved in the processes of growth and reproduction. Examples include isoprene, flavinoids, phytoalexins (medicarpin, rishitin, camalexin), thionins tanins and lignin.	Agrios, 2005

5.0 HOW DO PLANTS EXPRESS THEIR INFIRMITIES?

As stated earlier, diseased plants are inaudible. Modern science has not advanced enough to develop the capacity to hear them cry! I believe they do cry because the obvious signs and symptoms found on a diseased plant show that all is not well and the diseased plant is not enjoying the state. However, what is not discernable by sound has amply been accommodated by the outcome of series of studies deployed to understanding the visual responses of plant (and even pathogens) to invasion by fungal pathogens. Diseased plants express their 'discomfort' in an array of visual presentations on plant parts or the pathogen. A symptom is the external or internal reactions of alterations in a plant as a result of disease while a sign is the presence of the pathogen, its parts or products seen on a diseased host plant (Agrios, 2005). As diverse as the crop types and invading fungal pathogens are, so also are the manners of presentation and extent of disease symptoms and signs.

Plant pathologists, have therefore, crystallised the different symptoms and signs into describable groups that are now used to make primary inferences about plant diseases and their causal agents. It is important to note that symptoms and signs are primary indices of disease conditions. Specific diagnostic procedures that help to identify specific pathogens have been developed and are in use for the different types of plant diseases caused by fungi. The diagnostic procedures are pivoted on the Koch's postulate, a mantra in plant disease management. Koch's postulate literally helps to avoid 'calling' a fungus a 'thief' (pathogen) without 'following due process' to obtain evidence or witness to prove guilt.

Koch's postulate must be followed strictly before coming to conclusion that a fungus is the cause of any particular disease. This involves that:

(i) The suspected causal agent (fungi) must always and

constantly be associated with or present on the diseased plant.

(ii) The suspected causal agent (fungi) must be isolated from the diseased plant and grown in pure culture.

(iii) A pure culture must be inoculated into a healthy plant (of the same species), and the disease (similar to that observed in 1 above) must be produced on the inoculated plant.

(iv) The causal agent (fungi) must be re-isolated from the disease host (iii above) and confirmed to have the same characteristics as in (ii) above.

5.1 Symptoms and Signs of Fungal Diseases of common Plants in Tropical Environments.

Some symptoms and signs used to identify diseases and pathogens of tropical plants are summarised in Table 4:

Table 4: Some symptoms and signs of fungal diseases of common tropical plant diseases

Leaf Spots	Characterised by localised or restricted but defined nectrotic lesion on a leaf. A lesion is a mass of dead cells e.g. Cercospora leaf spot.
Blights	Rapid and extensive death of tissue of plant part. Sometimes, leaf spots coalesce to form blights. e.g Alternaria leaf blight.
Anthracnose	Dark brown to bla ck coloured wound-like necrotic lesions o n leaves, stem and or fruits caused by *Collectotrichum* species.
Die back	Extensive necrosis of twigs beginning at the tips and advancing towards their bases.
Wilt	Generalised loss of tugor and attendant drooping of leaves and shoots as a result of obstruction of vascular system. A transverse section of infected stems shown brown to dark brown discolouration of vascular bundle e.g. Fusarium wilt of tomato.
Rust	Aggregation of small lesion covered by profuse mass of fungal conidia. e. g. Soyabean rust, wheat rust.
Smut	Seed filled with the mycelium and black spores of causal pathogen e.g. Maize smut.
Mildew	Whitish mycelium and fruitification of fungal pathogen on leaves, stems and fruits of host plants e.g powdery mildew of cereals and annual weeds.
Soft Rot	Softening, discolouration and decay/disintegration of soft or succulent plant parts such as fruits, roots, tubers, bulbs and fleshy leaves. e.g. Soft rots of Tomato, Onion bulbs, vegetable, yam tuber etc.
Hard Rot	Hardening, discolouration and n ecrosis of erstwhile soft plant parts like tubers, roots etc. e.g. Hard rot of yam.

Damping-off	Rapid death and collapse of young seedlings e.g. Damping-off of tomato, cowpea and other annuals.
Basal Stem rot	Necrosis and disintegration of the lower (above-ground) parts of the stem leading to loss of strength and structural integrity e.g. Basal stem rot of wheat caused by *Sclerotium rolfsii*.
Canker	Localised or sharply delineated, dry necrotic lesions on stem or fleshy organ of the plant. Infected tissues appear sunken, depressed and crusty.
Seed rot	Profuse growth of fungi mycelium on seeds leading to rotting and loss of morphology and viability.
Seed Discolouration	Change in the natural colour of seeds as a result of internal and or external growth of fungi.
Head blight	Whitish light yellow to pinkish conidia mass of *Fusarium* spp. on wheat heads with straw-coloured to light brown discolouration of infected glumes.

Source: Mehrothra and Aggarwal (2004), Agrios (2005)

When the symptoms and/or signs observed on an infected plant agree with the outcome of pathogenicity test, an associated fungus is confirmed as the pathogen. From there, the knowledge of the features and characteristics of the pathogen-host-environment relationship is used to proffer management options that seek to save the plant from invasion by the fungal pathogen.

The knowledge gained from the careful study of healthy and diseased plants have helped man to overcome the challenge of inaudibility and immobility of diseased plants. Plants are getting protected anyhow!

6.0 PRINCIPLES AND PRACTISES OF FUNGAL DISEASE MANAGEMENT

The art of saving plants from the siege orchestrated by the fungal pathogen is as old as man. Recent advances have only helped to conceptualise these into understandable forms. Hence, the different methods being used in the management of plant diseases can be seen in one or combination of three principles namely:

i) Exclusion principle
ii) Protection principle
iii) Eradication principle

(Enikuomehin, 2012)

6.1 Exclusion Principle

This principle seeks to prevent the entry of a pathogen into a

particular location or host plant that is pathogen-free. This is achieved through several crop protection methods such as quarantine and regulatory measures, crop certification, evasion and avoidance of pathogen (through adjustment of sowing/planting time), as well as use of pathogen-free vegetative and reproductive units of propagation (Agrios, 2005). The crux of this principle is that the pathogen has not made contact with the host plant or entered the location where the host plant is situated. Therefore, any effort that helps to sustain the absence of the pathogen from accessing the host or environment is effectively hinged on the exclusion principle (Enikuomehin, 2012).

6.2 Protection Principle

This principle defines any effort aimed at ensuring that despite the presence of the pathogen within the precincts of the host plant, an effective host-pathogen relationship (Disease condition) is not established. This means that the infection of the host by the pathogen is prevented through physical and/or non-physical barriers such as use of resistant varieties/cultivars, chemical dressing of disease-free seeds or other propagating units, as well as seed coating with biological agents (Enikuomehin, 2012).

6.3 Eradication Principle

This principle underscores the fact that a disease condition is most likely to occur especially because the pathogen is present in sufficiently high inoculum level, the host is susceptible and the environment is enabling. Therefore, attempts are made to distract the normal cause of disease development through several methods targeted primarily at the pathogen. Plant disease management methods that are based on the eradication principle include:

- Cultural methods such as intercropping, crop rotation, tillage practises, rouging, sanitation (bush burning) and creation of other conditions that are unfavourable for pathogen survival or proliferation.

- Physical methods like soil sterilisation by heat, soil solarisation and hot-water treatment of propagating units.
- Chemical methods like foliar spray, soil drenching and seed treatment
- Biological control methods using antagonists and suppressive soil conditions.
- Seed treatment and foliar spray with plant products such as crude extracts, saw-dust, extracts, effluents and ash.

A method or practice can be used to serve two or more principles, depending on the circumstances. For example, chemical seed dressing could help forestall the infection of pathogen-free seeds sown in infested soil (protection) while serving as an eradicant on the sown seeds that carry latent inoculum of the pathogen. Similarly, crop rotation could ensure that inoculum level of an existing pathogen is reduced through cultivation of non-host plants (eradication) just as it could also be designed to ensure disease escape (exclusion) if the host is introduced after a period of rotation or fallow that has eliminated pathogen inoculum (Enikuomehin, 2012).

The different methods of plant disease management in Nigeria and their adaptability for resource-limited farming systems are presented in Table 5.

Table 5: Methods of fungal disease management and their adaptability in resource-limited farming systems in Nigeria.

Method	Principle(s)	Specific Practices	Adaptability in Nigeria	Way forward
Quarantine and regulatory measures, crop certification	Exclusion	* Deliberate polices and restrictions that limit introduction or spread of pathogens. * Inspection programmes for imported plants and plant products/parts	*Adaptable in Nigeria through policies and programmes that specify the peculiar requirements. However, programmes require highly trained and skilled personnel as well as modern equipment (resources) for pathogen identification and disease diagnosis.	* Implementation of existing policies * Renewed effort at capacity building and infrastructural development. * Development of policies for crops that are indigenous to Nigeria.
Use of resistant cultivars and varieties.	Protection	*Development, introduction and use of crop varieties of known resistance/tolerance to specific diseases	*Adaptable. However, its challenges are: resistance break down, non - acceptability of the resistance varieties by farmers , mix-up and fraudulent practices of middle men, non-availability of resistant varieties of crops that are of interest to farmers	*Bottom –up approach to research into crops which are of relevance in each locality *Improved distribution and supply mechanisms

Synthetic Chemical control of disease agents	Protection Eradication	*Foliar sprays or dusts *Seed dressing/coating *Soil drenching	*Adaptable and most efficient. However, it is of limited value in resource-limited agricultural schemes in Nigeria due to: Environmental pollution, human toxicity, high cost, adulterations and irregular supply.	*The need to highlight the value of IPM in relation to use of synthetics *Deploy location/farmer -specific approach to addressing these constraints
Botanicals (Plant products)	Protection Eradication	*Foliar spray with crude extracts of different plant parts *Seed dressing/coating with ash, saw-dust and granulated plant products *Seed sorting with brine	*Adaptable and in use in some rural agriculture systems ; Has great potentials, Less cost intensive because of the availability of materials within the farmers living environment, environment-friendly. *Overall potential still underutilized.	*Require more scientific evaluations in order to regulate use, validate efficacy, and the overall economic value. *The use to be encouraged via incentives, user education, etc
Cultural Methods	*Eradication *Exclusion	*Crop rotation *Intercropping, (mixed cultivars, mixed cropping, strip cropping) *Designing harvesting to avoid pathogen build-up *Roguing *Trap/barrier cropping *Repellant cultivars	*Most cultural methods are traditional to rural farming systems in Nigeria. *Less cost intensive, environment friendly, enhance effective resource (e.g. land) utilization, ensure an all year round economic return *Bedevilled by lack of scientific innovations in the specific areas (crops, environment and pathogens) that are of importance to the farmer.	*Renewed research efforts to develop specific practices for specific crops and locations. *Less emphasis of monocropping as most ideal in resource-poor farming systems. *Effective dissemination of information and Integrated Plant Health Management practices.
Physical methods	Eradication	*Hot-water treatment of seeds and propagating units. *Solarization and mulching with organic matter *Hand picking *Seed sorting prior to planting	*Methods are effective but in limited use in Nigeria. *There is little information on the physical disease control methods of the indigenous crops that are of interest to resource- limited farmers in Nigeria.	*Research into the methods and conditions specific to crops of interest to farmers should be undertaken.
Biological control	*Eradication *Protection	*Plant/seed treatment with antagonistic organisms.	*Method is proven to be effective but its use is limited in Nigeria agriculture.	*Improved access to effective bioagents, capacity building and infrastructural development.

Source: Enikuomehin (2012)

7.0 MY RESEARCH CONTRIBUTIONS TO PLANT DISEASE MANAGEMENT

In the melee that characterized the tussle between plants and fungal pathogens, I took side. I identified with and supported plants by studying fungal pathogens to gain enough understanding with which to work against them. I am conscious of the fact that fungal pathogens have a right to existence and do know that they will live despite my choice. Effective plant disease management options must stem from the understanding of the specific Host-pathogen relationship within an enabling environment. Furthermore, the challenge being faced by resource-limited farmers should be the driver of plant disease management efforts

in an environment like ours.

My involvement with plant disease management started when I was assigned to do the undergraduate project with Late Dr. S. A. Emua at the Department of Botany, Bendel State University, (now Ambrose Alli University), Ekpoma in 1987. This, as coincidental as it seemed, was a fulfilment of my childhood dream to become like my uncle, Late Dr. F. O. Aderungboye, a renowned Plant Pathologist and former President of Nigerian Society for Plant Protection (NSPP) (1982 – 1984). I was assigned a project to investigate the "Fungi associated with *Cola* species in storage". I got involved with passion and could recall vividly that I observed (albeit in my own small way!) that the leaves of *Mitragyna ciliata* was a source of contamination of kolanuts in storage, especially because such leaves were not washed before use to package kolanuts. This observation was never published and therefore did not enjoy the certification inherent in peer review. However, it stands out as my earliest memory of my effort at taking sides with the plant against invading fungal pathogens. My research efforts took cognisance of these and can thus be summarised in these sub-heads:

i) Identification of pathogens of crop plants
ii) Assessment and evaluation of plant diseases
iii) Use of plant products and intercropping (endowments of nature) as viable options in plant disease management

7.1 Identification of Pathogens of Crop Plants

For a disease to be managed properly, the identity of the causal agent (pathogen) must be ascertained. This is usually taken for granted, especially when symptoms have become identifiable and common with specific diseases. However, the dynamics of nature and its inherent diversity requires that specific attempts are made to identify every pathogen in every disease situation with attendant features and characteristics of the pathogen ascertained.

7.1.1 Studies on Fungal Pathogenicity on Rain-fed Wheat (Triticum aestivum)

In the early 1990s, there was a directive from the Federal Government to states in South- western Nigeria to cultivate wheat as a rain-fed crop. This wave necessitated the investigations into the pathology of the crop, especially when the only related scientific reports available then were those of Tyagi and Olugbemi (1980) and Anaso *et al.* (1980). Thus, the pathogenic potentials of fungi associated with disease of rain-fed wheat were investigated in order to understand their overall impact on rain-fed wheat cultivation in South-western Nigeria.

In the various reports that emanated therefrom (Enikuomehin 1995; Enikuomehin and Bankole 1998; Enikuomehin *et al*., 1998), it was obvious that rainfed wheat cultivation in South-western Nigeria is not profitable. The adverse effect of fungal diseases confirmed this observation. Specifically, post-emergence seedling death, basal leaf and boot blight, head blight and leaf spot caused by *Sclerotium rolfsii*, *Rhizoctonia solani*, *Fusarium graminearum* and *Curvularia lunata* respectively, were the major diseases of rain-fed wheat. Post-emergence seedling death (also known as Sclerotium foot rot) was a major problem to which all cultivars were susceptible. Incidence of disease was as high as 42.5% in a susceptible cultivar (Sonalika) (Table 6).

Table 6: Incidence of seedling disease of rain-fed wheat between 1993 and 1995 in Ibadan, Nigeria

Cultivar	Disease Incidence (%)		
	1993	1994	1995
Sonalika	39.6±7.40f	43.6±2.16e	42.5±6.24e
Siette ceros	7.21±.20cd	22.7±2.50c	11.2±1.42c
Pavon 76	15.5±2.36e	28.9±6.41d	15.06±2.92d
Indus 66	6.9±4.38c	18.6±11.36b	10.2±1.80bc
KAL/BB/TOB2/TC	3.4±1.32b	7.5±10.30a	6.2±4.51ab
BUS'S'/NAC'S'	5.5±1.32b	6.4±3.82a	4.5±5.26a
Mean	13.87	20.81	14.91

Values within a column followed by the same letters are not significantly different at P<0.05 (Duncan's Multiple Range Test) (±Standard Error)
Source: Enikuomehin and Bankole (1998)

The disease developed 6 to 10 days after planting and infected seedlings died by the 12th day. However, wheat seedlings that were not infected by the 12th day escaped the disease (Enikuomehin and Bankole 1998). As required by Koch's postulate, the involvement of *F. graminearum* which was isolated alongside *S. rolfsii* in infected tissues was investigated. *Fusarium graminearum* was found to be a secondary invader of *S. rolfsii*-infected tissues. It exhibited antagonistic potential against *S. rolfsii* as it delayed the establishment of *S. rolfsii* in the soil and totally prevented seedling infection when both organisms were introduced into the soil at the same time. However, the suitability of *F. graminearum* as an antagonist on wheat is of limited value. This is because *F. graminearum* is the cause of the head blight disease of wheat (Enikuomehin, 2005a) and a soil borne inocula will readily serve as source of subsequent head infection (Enikuomehin and Bankole, 1998).

Conversely, five fungal species isolated alongside *S. rolfsii* from ungerminated seeds were observed to present better options as candidate antagonists to *S. rolfsii* on wheat (Enikuomehin and Bankole, 1998). *Aspergillus flavus*, *A. tamarii* and *Choanephora* sp. did not induce significant reductions in seedling emergence when seeds were sown in soils infested with any of them. However, they individually prevented *S. rolfsii* from inducing significant reductions in seedling emergence when any of them was introduced into the soil at the same time with *S. rolfsii* (Table 7). Hence, these fungi species are candidates for the biological control of *S. rolfsii.* Further practical import of these observations is the possibility of finding natural antagonists to other necrotrophic soil-borne pathogens from the rhizosphere.

Table 7: Effect of fungi associated with ungerminated wheat seeds on seedling emergence, seedling length and vigour

Treatment	Seedling emergency (%)	Root length (cm)	Shoot length (cm)	Vigour index ($x10^3$)
Fusarium sp.	88.5ab	11.7cd	29.6b	3.7ab
Choanephora sp.	91.0ab	12.1bcd	32.3a	4.0a
Sclerotium rolfsii	33.0e	8.1gh	26.7d	2.9cde
Aspergillus flavus	90.0ab	16.6a	22.5ef	3.5abc
A. tamarii	91.5ab	9.5efg	23.2ef	3.0bcde
Fusarium sp. */ S. rolfsii*	82.5abc	8.1gh	20.3gh	2.4efg
Choanephera sp*/ S/rolfsii*	63.0d	13.2bc	29.3bc	2.7def
A. flavus / S. rolfsii	88.0ab	9.6efg	15.4k	2.2fg
A. tamarii/ S. rolfsii	75.0bcd	7.6h	17.6j	1.8h
Choanephora sp*/ Fusarium* sp.	80.5abc	10.4def	34.9a	3.6ab
A. tamarii / Fusarium sp.	83.0abc	11.5cde	21.2fg	2.8def
A. tamarii / A flavus	91.5ab	12.3bcd	23.4ef	3.2g
A. tamarii / Choaenphora sp.	70.0cd	9.3fgh	19.0hi	2.0g
A. flavus / Fusarium sp.	82.5abc	9.7efg	19.4ghi	2.5efg
A. flavus / Choanephora sp.	92.5a	10.7def	24.3e	3.2bcd
Choanephora sp */ Fusarium* sp. */ S. rolfsii*	90.5ab	11.6cd	27.6de	3.6abc
All fungi combined	90.0ab	14.1b	19.2hi	2.9bcde
Control (Uninfested sterile soil)	94.0a	17.9a	30.2b	4.1a

Values along the column followed by same letters are not significantly different ($P<0.05$) by Duncan's Multiple Range Test
Source: Enikuomehin and Bankole (1998)

Seeds are usually carriers (agents of transmission) of fungi which can ultimately infect seeds and foliage of mature plants. The importance of seed-borne fungi of wheat in disease development was investigated. Enikuomehin and Bankole (1998) reported that seed-borne *Helminthosporium sativum*, *Curvularia lunata* and *F. graminearum* are pathogenic to wheat seeds, reducing seed viability by a range 2.2 to 8.0% (Table 8). Reduction in seedling emergence was between 6.63 and 13.3% while the mixture of *C. lunata* and *F. graminearum* induced significantly higher reduction ($P< 0.05$) in seedling germination than either fungus alone (Table 8). *Fusarium Graminearum* induced 85.3% and 84.2% reduction in grain weight when plants were infected at flowering and boot stages respectively. Therefore, seed-borne inoculum of wheat is a potential source of infection of mature plants.

Table 8: Effect of seed-borne fungi on seed germination, seedling emergence and growth of wheat

Fungal species (Treatment)	Seed germination (% reduction)	Seedling emergence (% reduction)	Shoot length (cm)	Root length (cm)	Vigour index ($\times 10^3$)
H. sativum (Hs)	8.03a	12.61ab	22.45b	8.47e	2.60e
C. lunata (CL)	4.41a	12.24ab	20.83bc	13.12b	2.90cde
F. graminearum (Fg)	2.22c	6.63d	24.25ab	12.79bc	3.57b
Hs+CL	4.92bc	8.29bc	21.92b	13.35d	2.91cde
Hs+Fg	2.68c	9.52bc	18.46c	11.50cd	2.83de
CL+Fg	5.65ab	13.30a	23.71ab	12.96bcd	3.12cd
HL+CL+Fg	4.03bc	10.12b	24.07ab	11.55cd	3.28bc
Control	-	-	27.21ab	15.79a	4.26a
SE±	0.68	0.80	0.86	0.76	0.17

*Values are means of 4 replicates. Means with same letters in each column are not significantly different (P< 0.05) according to Duncan's Multiple Range Test.
Source: Enikuomehin and Bankole (1998)

Table 9: Effect of seed -borne fungi on grain yield of wheat plants infected at different stages of growth

	Mode of infection*				
Fungal species (Treatment)	Foliar Inoculation (3 wks)	Injured root inoculation (3 wks)	Uninjured root inoculation (3 wks)	Root inoculation (Before flowering)	Flower inoculation (at flowering)
F. graminearum	43.11b	40.07b	7.33b	84.18a	85.35a
H. sativum	46.76a	55.96a	10.9a	62.34b	62.23b
C. lunata	41.18c	10.77c	1.48c	48.88c	45.45c
SE±	1.33	10.80	2.24	8.39	9.44

Values are means of 4 replicate s each of 5 plants (ears) per replicate. Means with same letters in each column are not significant different (P <0.05) according to Duncan's Multiple Range Test.
* Reduction in grain weight (%)
Source: Enikuomehin and Bankole (1998)

7.1.2 Studies on Fungal Pathogenicity on Sesame (Sesamum indicum L.)

Sesame is an important oil seed crop that has great potential for economic development in Nigeria (Olowe, 2019). It is primarily grown in the derived savannah agro-ecology comprising Jigawa, Benue, Kwara, Kogi and Niger States of Nigeria (Busari *et. al*., 1998). However, the crop found promise in the 'agric-culture' of forest/savannah agroecology of South West Nigeria. Ironically, as at 1997 there was no record on the pathology of sesame in South West Nigeria. This created a gap in assessment of the crop for adaptability and cultivation in this part of the country. The need to fill this obvious gap was a necessary step towards entrenching the place of sesame as a viable crop for economic growth of farmers and exporters. This geared my interest in this crop. Therefore, my research and reports on the crop in Abeokuta, a forest/savannah transition agroecology in South-western Nigeria provided the basis for other research efforts on the pathology of the sesame crop in this part of the country. In the foundation studies conducted in Abeokuta, the major diseases of sesame were found to be Cercospora leaf spot and Alternaria leaf blight diseases (Enikuomehin *et. al*., 2002; Oduwaye and Enikuomehin, 2013). These diseases are among the several others reported on the crop in other parts of the world. However, ascertaining the identity and pathogenicity of fungi associated with these diseases in Abeokuta was a basic requirement for the management of the diseases. In the report of Oduwaye and Enikuomehin (2013), *Cercospora sesami* Zimm. was confirmed as causal agents of the Cercospora leaf spot disease (Plate 1). Plate 2 shows the typical Alternaria leaf blight symptom while Plate 3 indicates the look of a healthy Sesame plant.

Plate 1: Typical symptom of Cercospora leaf spot disease of sesame
Source: Author

Plate 2: Typical symptom of Alternaria leaf blight of sesame
Source: Author

Plate 3: Uninfected (Healthy) sesame plant
Source: Author

These fungal pathogens of sesame also have the ability to reduce the viability of infected seeds. These verifications encouraged the next phase of research efforts, which was to understand more, the extent of 'harm' that the diseases could cause on the sesame crop.

7.2 Assessment and Evaluation of Plant Diseases

The knowledge of the causal agent of a disease (pathogen) helps to ascertain the extent of damage that is attendant to the pathogen. Different diseases of crops require different, but appropriate methods of assessment and evaluation. These methods must be adoptable with predictable outcomes. Indeed, every assessment method must consider the peculiarity of host-pathogen relationship in an environment to become appropriate. My contributions in this regard were primarily on the sesame crop in South West Nigeria.

Prior to my interest in the sesame crop, there was no assessment method or scale specifically designed to attend to the peculiarity of sesame diseases. Hence, an assessment method for sesame disease incidence and severity was developed (Enikuomehin *et. al*., 2002). For disease incidence, weekly assessments were done from three weeks after planting (3 WAP) and continued until 12 WAP. Two permanent quadrats (50 x 100cm) were randomly placed within each plot and the number of plants in each quadrat was counted from which number of plants with disease symptoms on leaf and/or whole plant was determined.

For disease severity, assessments were made on 13-week old plants using the count of lesion number and rating of symptom expression through a visual score scale developed from a careful observation of the profile of disease development. For count of lesion number, five plants per plot were selected and on each plant, the number of lesions on a quarter (1/4) of the area of one leaf at the second node was counted. Another set of five plants per plot were randomly selected and rated for symptom expression using a visual score scale (Table 10). This disease incidence and severity assessment method has found wide acceptance since it was first

published and has evidently helped plant pathologists across the world in the process of plant disease evaluation. In fact, the score scale has been modified for other oil crops such as sunflower (Egbontan, 2019).

Table 10. Disease severity score for cercospora leaf spot disease of sesame

Scale	Rating	Cercospora Leaf Spot Characteristics
0	No Disease	No trace of infection
1	Hypersensitivity	Hypersensitive spot on lower leaves only
2	Trace Infection	Small lesions on lower leaves only
3	Slight Infection	Small lesions on lower and upper leaves and stem
4	Moderate Infection	*Advanced lesions on upper and lower leaves, with or without new infections on stem and petiole
5	Sever Infection	Advanced lesions on upper and lower leaves, flower, buds, stems and petiole and slight infection of pod
6	Very Severe Infection	All features of five above with severe infection of pod

*Advanced lesion is characterized by a dark to dark-brown spot with a whitish to straw-coloured or perforated centre
Source: Enikuomehin *et al*. (2002)

7.3 Use of Plant Products and Intercropping (Endowments of nature) As Options in Plant Disease Management

7.3.1 Plant Products in Plant Disease Management

The fact that there are concerns about the use of synthetic fungicides in agricultural systems in developing countries is not in doubt. However, what is contentious is the practical economic and environmental health values as well as appropriateness of the alternatives that have been proffered. These alternatives include the use of biological control agents, plant products (extracts, ash etc), ecosystem adjustment among others.

In the course of my research, I observe that efforts have always been made to address disease challenges in tropical environments (and in particular among resource-limited farmers) from the perspective of agricultural systems and crop protection strategies of the developed countries. This is the reason the debate on whether or not farmers can survive without 'a bit' of fungicides still

surfaces in our conferences and discussion sessions. The concept of organic agriculture for example, is defined strictly as prescribed by developed countries. In a simple sense, the concept is not alien to the resource-limited farmer in the rural villages of southern Nigeria where there is no access to pesticides or fertilizers. I believe that there is the need to adopt a bottom-up approach to crop protection, especially when the focus is to address the need of resource-limited farmers. The so-called resource-limited farmers, who I also call subsistent farmers, have a better understanding of the environment, crops and disease history than anyone else outside their ecosystem. While their knowledge may not be accurate or specific enough to sustain a long term and/or accurate response to disease incidence and pressure, it will no doubt provide the basic insights that will help the researcher to fashion strategies that will not be alien to the farmer. By this, the non-acceptability of new strategies and the attendant mutual suspicion will reduce. In the same vein, disease management methods must be easy to adopt and affordable in terms of the process and cost.

This belief system was what fuelled my passion for research into the use of plant products as tools for crop protection. Plants contain anti-microbial agents that reduce the level of disease severity in crop plants. However, the demand to always determine the active ingredient of any plant with proven antifungal (or anti-microbial) efficacy has reduced the pace at which these options become translated to practical value for the farmer. I believe that the determination of the active ingredient of an efficacious plant product is important, but not necessarily a first step before the practical use of the option by the farmer. Indeed, the knowledge of the active ingredient is of no practical value to a resource-limited farmer. What he/she needs is the knowledge of what, how and when to use the plant product in the most affordable and convenient way to achieve better crop protection, and ultimately better value for his/her effort.

7.3.1.1 Ash of Tropical Plants in Disease Management

My contribution to the concept of plant products in plant disease management started with the observation that ash of some tropical plants reduced mycelial growth of seed-borne pathogens of wheat (Enikuomehin, 1995). Specifically, wood ash of *Delonix regia* (Flamboyant tree) induced up to 77.8, 80.7 and 88.8% reduction in the mycelial growth of *Helminthosporium sativum*, *C. lunata* and *F. graminearum* respectively. *Ricinus communis* (Castor bean) leaf ash reduced mycelial growth of *C. lunata* by 70.0% while *Eichornia crassipes* (Water hyacinth) ash induced 88.3% reduction in the mycelial growth of *F. graminearum in vitro* (Enikuomehin and Kehinde, 2007) (Table 11). Similarly ash of *D. regia* wood, *Mangifera indica* (Mango) leaf and *Vernonia amygdalina* (Bitterleaf) leaf totally inhibited the mycelial growth of *S. rolfsii in vitro* (Enikuomehin *et. al*., 1998) (Table 12). *Mangifera indica* leaf ash delayed *S. rolfsii* sclerotia germination on agar (Plate 4), while neem leaf ash delayed *S. rolfsii* sclerotia production *in vitro* (Plate 5). The effect of ash of *E. guinensis* (Oil palm) fruit shaft, *D. regia* wood and *A. indica* leaf on mycelial growth of *S. rolfsii in vitro* is shown in Plate 6.

In *S. rolfsii*-infested soils, ash of some tropical plants protected wheat seeds from pre-emergence rot and post emergence seedling infection (Sclerotium foot rot) (Table 13). These observations are useful for integrated plant disease management in tropical environments because the different plants are readily available within the farmers' living environments and the process of obtaining ash is not alien to the farmer. Similarly, the options give value to plant products that hitherto had no value. Furthermore, these options provide affordable and effective means of containing the adverse effects of *S. rolfsii*, a pernicious and highly destructive soil-borne pathogen of almost every crop plant.

Table 11 : Reduction of mycelial growth of *Curvularia lunata*, *Helminthosporium sativum* and *Fusarium graminearum* by ash samples from tropical plants

Ash sample	Ash concentration (%)	Mycelial growth reduction (%)				
		C. lunata	*H. sativum*	*F. graminearum*	Mean	LSD (P<0.05)
Azardirachta	5	53.5	31.7	40.6	-	-
indica (leaf)	10	56.4	48.9	50.7	-	-
	15	61.3	55.4	58.2	-	-
Mean	-	57.1	45.3	49.8	50.7	8.19
LSD (P<0.05)	-	5.42	16.8	12.5	-	-
Delonix regia	5	53.1	59.9	81.2	-	-
(wood)	10	69.5	72.2	83.9	-	-
	15	80.7	77.8	88.8	-	-
Mean	-	67.7	69.9	84.6	74.0	12.6
LSD (P<0.05)	-	19.1	12.6	53.0	-	-
D. regia (leaf)	5	44.8	17.9	31.7	-	-
	10	61.9	41.9	41.7	-	-
	15	66.4	47.6	51.0	-	-
Mean	-	57.7	35.8	41.5	45.0	15.6
LSD (P<0.05)	-	15.7	21.7	13.3	-	-
Eichornia crassipes	5	38.6	47.7	73.2	-	-
(leaf)	10	45.0	53.2	81.5	-	-
	15	54.2	56.3	88.3	-	-
Mean	-	45.9	52.4	81.0	59.7	25.7
LSD (P<0.05)	-	10.8	5.9	10.4	-	-
Mangifera indica	5	47.8	38.6	40.8	-	-
(leaf)	10	55.7	44.1	46.6	-	-
	15	58.7	45.5	51.2	-	-
Mean	-	54.1	42.7	46.2	47.6	8.03
LSD (P<0.05)	-	7.75	5.0	7.2	-	-
Ricinus communis	5	70.1	30.5	59.2	-	-
(leaf)	10	71.5	39.7	61.6	-	-
	15	73.3	45.5	66.1	-	0
Mean	-	71.6	62.3	38.5	57.4	23.4
LSD (P<0.05)	-	2.21	10.4	4.9	-	-
Elaeis guineensis	5	30.3	21.0	16.4	-	-
(fruit shaft)	10	33.3	22.1	39.1	-	-
	15	35.3	27.8	71.3	-	-
Mean	-	32.9	23.6	42.2	32.9	12.8
LSD (P<0.05)	-	3.46	5.0	37.9	-	-
E. guineensis	5	28.9	21.0	10.7	-	-
(inflorescence)	10	31.0	25.6	23.1	-	-
	15	29.5	29.4	51.9	-	-
Mean	-	29.9	25.3	28.6	27.9	3.26
LSD (P<0.05)	-	1.45	5.79	29.0	-	-
Vernonia	5	57.1	28.7	24.7	-	-
amygdalina	10	56.1	28.9	27.8	-	-
(leaf)	15	56.4	32.9	39.7	-	-
	-	56.5	30.1	30.7	38.9	20.4
Mean	-	7.06	3.26	10.8	-	-
LSD (P<0.05)	5	60.4	50.4	17.6	-	-
	10	62.1	51.6	34.5	-	-
Musa spp.	15	66.9	55.6	64.2	-	-
(flower bract)						
	-	63.1	52.5	38.7	51.3	16.8
Mean	-	4.64	3.74	32.4	-	-
LSD (P<0.05)	5	35.3	43.0	71.0	-	-
	10	41.5	46.7	75.0	-	-
Ocimum gratissimum	15	47.4	51.7	76.5	-	-
(leaf)						
Mean	-	41.4	47.1	74.2	54.2	24.1
LSD (P<0.05)	-	8.32	6.0	3.91	-	-

Values are means of three replicates per treatment
Source: Enikuomehin and Kehinde (2007)

Table 12: Inhibition of mycelial growth of *S. rolfsii* by tropical plant ash samples after 6-day incubation at 28±2^{0}C

Ash samples	Inhibition of mycelial growth (%)		
	Ash concentration (treatment)		
	5%	10%	15%
Delonix regia (wood)	100.0[a]	100.0	100.0
D. regia (leaf)	55.0	68.6	87.2
Mangifera indica (leaf)	100.0	100.0	100.0
Ocimum gratissimum (leaf)	73.0	100.0	100.0
Azadirachta indica (leaf)	49.6	53.0	100.0
Musa paradisiaca (flower bract)	0.00	100.0	100.0
Ricinus communis (leaf	0.00	100.0	100.0
Elaesis guineensis (fruit shaft)	11.2	19.4	29.5
E. guineensis (female infl.)	10.9	22.0	24.3
Vernonia amygdalina (leaf)	100.0	100.0	100.0
Eichornia crassipes (whole plant)	0.00	0.00	0.00
LSD (P<0.05)	54.9	50.3	49.2

[a] Values are means of 4 replicate plates of fungus per ash treatment
Source: Enikuomehin *et al.* (1998)

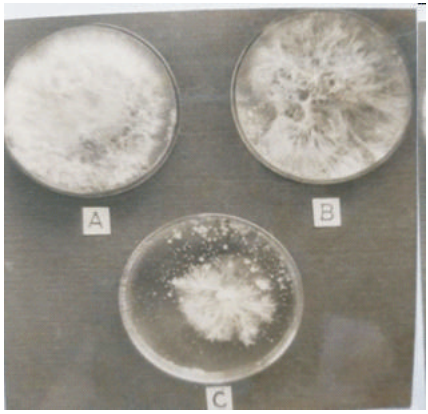

Plate 4: Twenty-seven days old cultures showing the growth of *S. rolfsii* generated by inoculating sclerotium on plate containing *M. indica* leaf ash, A:5% *M. indica* (leaf) ash; B: 10% *M. indica* (leaf) ash; C: 15% *M. indica* (leaf) ash. **Note:** The fluffy mycelium on A (5%) in relation to the dichotonmous and branched growth pattern on B (10%) and the colony size and pattern on C (15%)
Source: Enikuomehin (1995)

Plate 5: Twenty-seven days old cultures indicating the growth of *S. rolfsii* showing suppression of sclerotia formation in agar by Neem leaf ash: A: Control (No ash); B: 5% Neem leaf ash; C: 10% Neem leaf ash. **Note**: Some whitish sclerotia primordial present in B (5%) are not present in C (10%).
Source: Enikuomehin (1995)

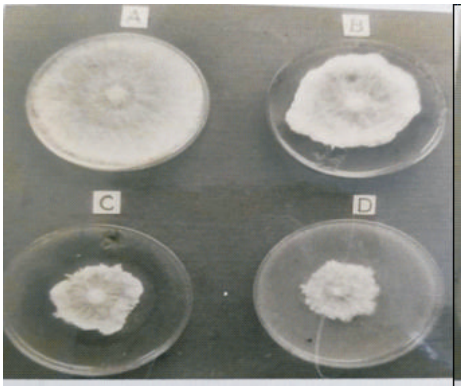

Plate 6: Response of *Sclerotium rolfsii* to 5% (w/v) concentration of ash from different plants showing suppression of mycelial growth after 7days incubation at 28±2^{0}C: A: Control (No ash); B: Oil palm fruit shaft ; C: Neem leaf ash ; D: flamboyant leaf ash.
Source: Enikuomehin (1995)

Table 13: Effect of ashes on wheat seedling emergence and post-emergence disease development in *S. rolfsii*-infested soil

Ash source (treatment)	Seedling emergence (%)[a]	Seedling root length (cm)[b]	Seedling shoot length (cm)[b]	Symptom development and general observation on rhizosphere 14 days after sowing
Mangifera indica (leaf)	78.75	3.06	8.75	No-fungal growth within root zone containing ash dust. No root or crown infection.
Vernonia amygdalina (leaf)	48.00	8.72	13.56	No root or crown infection. No fungal growth within root zone. *S. rolfsii* recovered from ungerminated seeds.
Azadirachta indica (leaf)	44.00	6.30	10.85	No root or crown infection. Ash inhibited fungal growth within root zone. *S. rolfsii* recovered from ungerminated seeds
Ricinus communis (leaf)	44.00	6.30	10.42	Ash delayed fungi establishment. Leaf, root and crown infection just being initiated by 14th day. *S. rolfsii* was recovered from ungerminated seeds
Musa paradisiaca (leaf)	33.00	5.40	6.56	No root or crown infection. No fungi growth within root zone. *S. rolfsii* recovered from ungerminated seeds. Seedling had weak stands.
Eichornia crassipes (whole plant)	36.00	5.32	7.50	There was ro ot and crown infection with 50% seedlings killed. *S. rolfsii* recovered from ungerminated seeds
Elaeis guineensis (inflorescence)	20.00	2.42	5.21	There was severe root and crown infection leading to death of 60% of seedlings. *S. rolfsii* recovered from ungerminated seeds
E. guineensis (fruit shaft.)	15.00	2.13	5.75	There was severe root and crown infection with 80.0% seedlings killed. *S. rolfsii* recovered from ungerminated seeds.
Delonix. regia (wood)	3.00	ND	ND	All seedlin gs were dead by the 14th day. *S. rolfsii* recovered from dead tissues
D. regia (leaf)	0.00	ND	ND	*S. rolfsii* recovered from ungerminated seeds
Ocimum gratisimum (leaf)	ND	ND		S. rolfsii recovered from ungerminated seeds
Seeds in *S. rolfsii*-infested soil without ash (Control 1)	ND	ND		There was severe root and crown infested soil infection. All seedlings were killed by 14 th day. S. rolfsii recovered from ungerminated seeds
Surface-sterilized seeds in steam-sterilized soil without ash (control II)	88.00	10.14	15.65	ND
Least significant difference (LSD)P<0.05	16.56	1.94	2.61	

[a]Values of seedling emergence are means of 4 replicate s each of 25 seeds per replicate.
[b]Seedling root and shoot lengths are means of 5 plants in each of 4 replicates per treatmen t
[c] Percentage kill was calculated from seedling emergence in each treatment.

Source: Enikuomehin *et al*. (1998)

7.3.1.2 Plant Extracts in Plant Disease Management

Crude extracts of some plants found in the living environment of farmers in Nigeria have also been found to be efficacious in reducing disease incidence and severity. In a report by Enikuomehin and Peters (2002), cold water extracts of *Azadirachta indica* and *Ocimum gratissimum*, when sprayed at two weeks interval on the field significantly reduced the incidence and severity of Cercospora leaf spot and Alternaria leaf blight diseases of sesame. Fungal infection of seeds was also reduced by these treatments (Table 14).

Similary, another report by Enikuomehin (2005b) showed that aqueous extracts of *Aspilia africana*, *Chromolaena odorata* and *Tithonia diversifolia* substantially reduced the incidence and severity of Cercospora leaf spot disease, curtailed the pace of disease development which in turn protected flowers and capsules of sesame from infection (Table 15). This further resulted in significantly lower infection of seeds by fungi (Table 16). In all, leaf extracts of *A. africana*, *C. odorata* and *T. diversifolia* were comparable to a synthetic fungicide (Bentex T: Benlate 20% wp) in suppressing Cercospora leaf spot disease of Sesame (Enikuomehin, 2005b).

Table 14: Effect of plant extracts on incidence and severity of foliar diseases and seed infection of Sesame

Treatment	Cercospora leaf spot		Alternaria leaf blight		Seed Infection (%)
	Incidence * (Nf %)	Severity ** (Lesion no)	Incidence* (Nf %)	Severity*** (Lesion size) mm^2	
Ocimum gratissimum	68.5	30.9	19.5	14.0	4.3
Azadiarachta indica	72.8	34.1	26.3	19.8	6.1
Mangifera indica	81.4	42.5	33.7	28.8	7.1
Benlate	80.8	51.9	30.4	24.5	6.5
Control	89.1	66.7	40.2	41.4	8.9
LSD (P<0.05)	7.45	15.5	8.28	11.05	1.77

*Nf – No of leaves infected at 12WAP
**Lesion no per ¼ leaf area of one leaf at the second node obtained at 13WAP
***Lesion size obtained as mean from five leaves at 13WAP
Source: Enikuomehin and Peters (2002)

Table 15: Effect of field spray with plant extracts on the incidence and severity of Cercospora leaf spot disease in two cultivars of sesame (530-6-1 and Pbtil No.1) at Abeokuta, Nigeria.

Treatment	Disease incidence (%)				Severity assessment			
	Plant infected		Leaves infected		Lesions per ¼ leaf area		Disease score(±S.E)[2]	
	530-6-1[1]	Pbtil No.1	530-6-1	Pbtil No.1	530-6-1	Pbtil No.1	530-6-1	Pbtil No.1
Aspilia africana	78.7^{b}	57.1^{b}	31.7^{b}	40.0^{b}	7.7^{bc}	6.7^{b}	3.5±0.16	3.8±0.81
Chromoalena.odorata	68.8^{b}	75.4^{b}	31.2^{b}	38.3^{b}	6.2^{bc}	7.9^{b}	3.5±0.12	3.4±0.81
Tithonia diversifolia	82.5^{a}	75.6^{ab}	41.7^{b}	35.4^{b}	6.3^{bc}	5.6^{b}	3.7±+0.12	4.5±0.52
Musa paradisiaca	84.5^{a}	86.4^{a}	37.7^{b}	58.9^{ab}	8.3^{b}	7.1^{b}	4.0±0.14	3.5±0.47
Bentex T	56.1^{b}	56.2^{b}	22.0^{c}	19.0^{c}	4.7^{c}	5.7^{b}	3.3±0.47	3.5±0.47
Control	91.5^{a}	92.0a	72.5^{a}	70.3^{a}	12.4^{a}	13.2^{a}	4.5±0.41	5.3±0.94

[1]Values with dif ferent superscripts in the same column are significantly different (p<0.05) in Duncan's Multiple Range Test.
[2]Data are means (± standard error) of visual severity scores obtained 13 weeks after planting (WAP) from 15 plants per cultivar and within each treatment category. Plant s were scored on a 0-6 scale
Source: Enikuomehin (2005b)

Table 16: Seed mycoflora, germination of harvested seeds and grain yield of two cultivars of sesame (530-6-1 and Pbtil No.1) as affected by different herbal sprays at Abeokuta in Nigeria

Treatment	Fungal incidence (%)		Seed germination (%)		Grain yield (kg ha^{-1})	
	530-6-1	Pbtil No.1	530-6-1	Pbtil No.1	530-6-1	Pbtil No.1
Aspilia africana	8.8^{c}	7.3^{c}	78.5^{c}	83.0^{a}	110.0^{abc}	139.0^{ab}
Chromalaena odorata	8.0^{b}	7.0^{b}	77.0^{d}	81.0^{c}	104.9^{ab}	99.9^{bc}
Tithonia diversifolia	4.5^{a}	7.5^{c}	83.5^{b}	78.5^{d}	155.0^{a}	149.6^{ab}
Musa paradisiaca	10.0^{d}	10.5^{d}	74.5^{c}	65.5^{c}	100.0^{bc}	110.0^{abc}
Bentex T	4.5^{a}	6.5^{a}	89.0^{a}	82.0^{b}	146.4^{ab}	112.6^{abc}
Control	10.3^{d}	13.5^{a}	73.0^{f}	64.5^{f}	86.0^{c}	72.0^{c}

Values with different superscripts along the column are significantly different (P<0.05) in Duncan's Multiple Range Test.
Source: Enikuomehin (2005b)

The prospects of plant extracts being useful as protectant against tomato fruit rot was highlighted by the reports of Enikuomehin and Oyedeji (2008). In the report, aqueous and ethanolic extracts of *Alchornea cordifolia*, *Cassia alata* and *Moringa oliefera* significantly reduced the mycelial growth of tomato fruit rot pathogens; *Fusarium verticillioides* and *Macrophomina phaseolina in vitro* (Tables 17 and 18). In the study, the ethanolic extract of these plants exhibited stronger fungitoxicity than the aqueous extract, a tendency that is due to the inherent differences in the solubility of fungitoxic constituents in the extracting solvents (Amadioha, 2004). However, significant reduction in rot

of infected fruits was obtained with either aqueous or ethanolic extract of these plants when fruits were soaked for 1hr in the extracts before storage (Table 19). This observation shows that the level of post-harvest losses of tomato due to the effect of these rot fungi can be reduced with plant extracts using a process that is not cumbersome.

Typically, the method of obtaining aqueous extract of plants involves washing of harvested leaves in running tap water, determining the weight of the leaf material and macerating in a known volume of water. Macerated tissues are strained through 3 to 4 layers of muslin cloth after which the extract obtained is made up to the required volume by addition of the prescribed volume of water. This extract is ready to be sprayed on the field! (Figure 5).

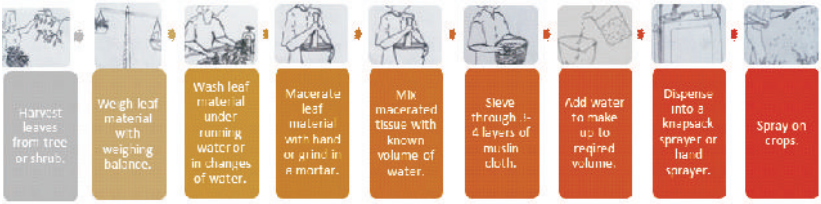

Figure 5: Schematic presentation of the process of production of plant crude extracts from plants
Source: Author

Table 17: Effect of aqueous and ethanolic extracts of *Cassia alata*, *Moringa oleifera* and *Achlornia cordifolia* leaf of mycelial growth of *Fusarium verticillioides* after seven days incubation at 28±2°C

	Cassia alata			*Moringa oleifera*		*Alchornia cordifolia*		
Plant Extract	**Conc. (mg/ml)**	**Radial Length (mm)**	**Mycelial Inhibition (%)**	**Radial length (mm)**	**Mycelial inhibition (%)**	**Conc. (mg/ml)**	**Radial Length (mm)**	**Mycelial Inhibition (%)**
Aqueous	10	68.3^{c}	21.5^{b}	77.0^{b}	11.5^{c}	3.0	62.3^{d}	28.4^{b}
	8	70.0^{c}	19.5^{b}	80.0^{b}	8.05^{ab}	2.5	71.0^{bc}	18.4^{a}
	6	79.0^{b}	9.20^{a}	81.7^{ab}	6.13^{ab}	2.0	77.0^{bc}	11.5^{a}
	4	78.3^{b}	9.97^{a}	81.7^{ab}	6.13^{ab}	1.5	77.3^{bc}	11.1^{a}
Ethanolic	10	40.7^{d}	53.3^{c}	26.7^{e}	69.3^{d}	3.0	77.7^{b}	10.7^{a}
	8	41.4^{d}	52.5^{c}	38.0^{d}	56.3^{e}	2.5	76.7^{bc}	11.9^{a}
	6	36.3^{e}	58.2^{d}	49.0^{c}	43.7^{b}	2.0	77.7^{b}	10.7^{a}
	4	36.0^{e}	58.6^{d}	46.7^{c}	46.4^{b}	1.5	74.7^{bc}	14.2^{a}
Control		87.0^{a}	-	87.0^{a}	-	Control	87.0^{a}	-

Data are means of three replicates per treatment and values followed by same letters along the column are not significantly different (P<0.05) in Duncan's Multiple Range Test.

Source: Enikuomehin and Oyedeji (2008)

Table 18: Effect of aqueous and ethanolic extracts of *Cassia alata*, *Moringa oleifera* and *Achlornia cordifolia* leaf of mycelial growth of *Macrophomina phaseolina* after seven days incubation at 28±2°C

Plant Extract	*Cassia alata*			*Moringa oleifera*		*Alchornia cordifolia*		
	Conc. (mg/ml)	*Radial Length (mm)*	*Mycelial Inhibition (%)*	*Radial length (mm)*	*Mycelial inhibition (%)*	*Conc. (mg/ml)*	*Radial Length (mm)*	*Mycelial Inhibition (%)*
Aqueous	10	87.0^{a}	0.0^{a}	52.0^{b}	40.2^{a}	3.0	74.4^{a}	14.3^{b}
	8	87.0^{a}	0.0^{a}	54.0^{b}	37.9^{a}	2.5	79.0^{a}	9.20^{ab}
	6	87.0^{a}	0.0^{a}	56.0^{b}	35.6^{a}	2.0	79.0^{a}	9.20^{ab}
	4	87.0^{a}	0.0^{a}	55.0^{b}	36.8^{a}	1.5	87.0^{a}	0.0^{a}
Ethanolic	10	14.0^{d}	83.9^{b}	0.0^{d}	100.0^{c}	3.0	34.7^{c}	60.2^{a}
	8	20.0^{c}	77.0^{c}	0.0^{d}	100.0^{c}	2.5	39.0^{c}	55.1^{d}
	6	23.0^{b}	73.5^{d}	22.3^{c}	74.0^{b}	2.0	41.7^{c}	52.1^{d}
	4	26.0^{b}	70.1^{d}	24.7^{c}	72.0^{b}	1.5	55.7^{b}	36.8^{b}
Control		87.0^{a}	-	87.0^{a}	-	Control	87.0^{a}	-

Data are means of three replicates per treatment and values followed by same letters along the column are not significantly different (P<0.05) Duncan's Multiple Range Test

Source: Enikuomehin and Oyedeji (2008)

Table 19 : Effect of aqueous and ethanolic plant extracts on tomato fruit rots induced by rot Pathogens

Treatment	Fruit decay (%) / plant extract	
	Aqueous	Ethanolic
A. cordifolia + *M. phaseolina*	6.9±2.4	9.3±0.4
M. oleifera + *M. Phaeolina*	6.7±0.5	6.3±1.4
C. alata + *M. Phaeolina*	3.6±1.4	8.1±3.3
M. phaseolina	28.6±2.5	
Control (Uninfected fruit)	1.3±2.5	
LSD (P<0.05) (Aqueous/ *M.phas*./control = 9.41; Ethanolic/*M.phas*./control = 8.98)		
A. cordifolia + *F. verticillioides*	6.3±4.6	9.3±0.8
M. oleifera + *F. Verticillioides*	3.3±1.5	7.3±2.3
C. alata + *F. Verticillioides*	5.6±1.0	3.2±0.1
F. Verticillioides	-	13.8±0.5
Control (Uninfected fruit)	-	1.3±0.5
LSD (P< 0.05) (Aqueous/*F.vert* ./control = 4.29; Ethanolic/*F.vert* ./control = 4.22)		

Source: Enikuomehin and Oyedeji (2008)

7.3.1.3 Studies on seed-borne mycoflora of sesame and their control with hand sorting and plant products

Seed treatments with plant extracts for improved viability and seedling emergence was also undertaken in various studies. Soaking of sesame seeds for 30 min or 60 min in 7.5 % (w/v) aqueous extract of *Musa paradisiaca* leaf or *T. diversifolia* leaf improved viability and lowered infection of seeds by fungi (Enikuomehin, 2005).

Seed-borne fungi constitute primary source of inoculum for infection of field crops. Infected seeds may or may not be physically deformed. Therefore, there is the need to evolve creative and simple means of separating infected from healthy seeds. Visual observation of seeds can be developed as a primary tool for separating diseased from healthy seeds (Enikuomehin, 1995)

Hand sorting of seeds have been effective in separating infected from healthy seeds of rice (Rahman and Mai, 2000) but the need for a method that can accommodate a larger volume of seeds per unit time was necessary. Quazi (2001) reported that salt density separated infected and healthy seeds of eggplant and tomato, while Kanobe *et.al.* (2004) reported the efficacy of salt density in sorting seeds of rice, eggplant, tomato and cowpea. For sesame, there was no consonance among available reports. While Mudingotto *et al.* (2002) reported that salt density was not effective in sorting diseased from healthy seeds, Kanobe *et al.* (2004) concluded that the report of Mudingotto *et al*. (2002) may be due to the low salt concentration (2.5 and 5%) used in the study. In response to this controversy, Enikuomehin (2010) investigated the effectiveness of four (2%, 5%, 10% and 15%) salt (Nacl) concentrations for sorting seeds of sesame and observed that, contrary to report of Mudintotto *et.al.* (2002) and the inference of Kanobe *et al.*(2004), 2% or 5% salt concentrations successfully separated diseased from healthy seeds of Sesame (Tables 20 and 21). A seed-borne fungus on sunken healthy seeds was also reduced by the salt treatment. This method is easily adoptable and it has the advantage of sorting seeds without visual abnormalities.

Table 20: Effect of seed sorting with salt solution on fungal infection of sesame cultivars

Treatment (salt concentration)	Fungal infection (%)*		
	530-6-1	NCRIBEN 03L	Pooled mean
Sunken Seed			
15%	12.1±1.7^{ab}	2.0±0.5^{a}	7.0^{a}
10%	8.0±1.3^{a}	7.2±1.3^{b}	7.6^{a}
5%	15.0±1.7^{bc}	7.2±2.8^{b}	11.1^{ab}
2%	15.3±1.7^{bc}	7.0±0.7^{b}	11.7^{b}
Floated Seed			
15%	15.3±1.5^{c}	0.5±0.1^{a}	7.9^{a}
10%	14.2±1.6^{c}	2.5±0.4^{a}	8.3^{a}
5%	35.6±1.5^{d}	8.7±0.8^{b}	21.4^{c}
2%	30.9±0.2^{d}	19.7±1.7^{c}	25.3^{d}
Unsorted seed (control)	17.7±2.3^{c}	9.3±0.5^{b}	13.5^{b}

*Data obtained from 400 seeds/treatment/cultivar placed on blotter. Values along column having the same superscripts do not differ significantly according to Duncan's Multiple Range Test ($P<0.05$).
Source: Enikuomehin (2010)

Table 21: Effect of seed sorting with salt solution on viability of sesame cultivars

Treatment (salt concentration)	Seed germination (%)		
	530-6-1	NCRIBEN 03L	Pooled mean
Sunken Seed			
15%	96.5^{c}	95.0^{c}	95.7^{c}
10%	96.6^{c}	97.5^{cd}	97.0^{cd}
5%	87.0^{b}	97.5^{cd}	92.3^{c}
2%	92.5^{bc}	97.5^{cd}	95.0^{cd}
Floated Seed			
15%	94.2^{c}	99.5^{d}	96.0^{cd}
10%	96.5^{c}	98.0^{cd}	97.3^{d}
5%	66.5^{a}	95.0^{c}	80.8^{b}
2%	65.0^{a}	82.0^{a}	73.5^{a}
Unsorted seed (control)	84.4^{b}	89.6^{b}	87.0^{b}

*Data obtained from 400 seeds/treatment/cultivar placed on blotter. Values along the column having the same superscripts do not differ significantly according to Duncan's Multiple Range Test ($P \leq 0.05$)
Source: Enikuomehin (2010).

7.3.1 *Studies on Intercropping in Plant Disease Management*

Intercropping is a system in which two or more crops are grown simultaneously or in temporal sequence on the same piece of land (Boudreau, 2013). This is a popular farming "culture" in tropical environments and in particular among subsistent farmers. It is proven to earn more earnings for the farmer whose income from the farm could extend until the end of the season because of the different crops cultivated on the farm.

Aside the yield and attendant gains that accrue to the farmer from

intercropped farms, intercropping has potential to reduce the incidence and severity of plant diseases (Gururaj *et al*. 2005; Ihejirika *et al*., 2010). Indeed, Boudreau (2013) reported that in a phenomenological research that compared diseases in monocrops and intercrops, primarily due to foliar fungi, intercropping reduced diseases in 73% of more than 200 studies. Hence intercropping is a viable plant disease management option that is less costly, environment-friendly and easily adoptable by the farmer. This fact caught my fancy and motivated my interest in exploiting the value of intercropping, an endowment of nature in sesame disease management. Interestingly, intercropping sesame with other crops was common among growers in Savannah agroecology of Nigeria. However, there was no information on the effect of intercropping on incidence and severity of foliar diseases of sesame in Nigeria. This paucity of information was addressed by the outcome of the research by Enikuomehin *et al*. (2010). The study confirmed that intercropping sesame with maize reduced the incidence and severity of Cercospora leaf spot and Alternaria leaf blight diseases of sesame. Specifically in the study, intercropping sesame with maize in single alternate row (1:1) arrangement induced significant reductions in incidence of Cercospora leaf spot, Alternaria leaf blight diseases and defoliation (Table 22). Diseases severity was lower (Table 23) while grain yield indices were more enhanced in 1:1 intercrop than sole plots (Table 24).

Table 22 : Maximum incidence of foliar diseases (M_f) and defoliation (M_d) of sesame as influenced by different row arrangements in sesame/maize intercrop in the first and second rainy seasons in 2005 at Abeokuta, Nigeria.

Season	Row arrangement**	Mf-CLS* (%)	Mf-ALB (%)	Md (%)
First	2:2	23.5^{b}	7.8^{d}	7.8^{b}
	2:1	35.8^{c}	8.5^{c}	7.3^{b}
	1.1	16.5^{a}	4.8^{a}	3.8^{a}
	Sole crop	75.5^{d}	15.2^{c}	17.0^{c}
Second	2:2	32.2^{b}	2.8^{ab}	3.2^{b}
	2:1	28.5^{b}	3.1^{b}	2.6^{ab}
	1.1	16.8^{a}	1.8^{a}	1.8^{a}
	Sole crop	56.5^{c}	7.2^{c}	8.6^{c}

*CLS – Cercospora leaf spot; ALB – Alternaria leaf blight. Disease incidence and defoliation were recorded 12WAP and 11WAP respectively for first and second seasons respectively

**Row arrangements; 2:2- sesame/maize in alternate pair of rows; 2:1-Alternate pairs of sesame to single row maize; 1:1-sesame/maize in single alternate rows; Sole crop-sole sesame different at $P \leq 0.05$ Means within a column of each season followed by same letters are not significantly according to Duncan's Multiple Range Test.
Source: Enikuomehin *et al*. (2010)

Table 23 : Disease severity of Cercospora leaf spot (CLS) and Alternaria leaf blight (ALB) of sesame as influenced by different row arrangements in sesame/maize intercrop in first and second rainy seasons in 2005 at Abeokuta, Nigeria.

	Severity index*		
	CLS		ALB
Row arrangement	Number of lesions per ¼ leaf area	Visual score**	Lesion size (mm^2)
First season			
2:2	34^{b}	4	3.40^{bc}
2:1	43^{b}	4	2.30^{a}
1.1	20^{a}	3	1.20^{a}
Sole	104^{c}	5	7.60^{c}
Second season			
2:2	28^{b}	4	3.10^{bc}
2:1	28^{b}	4	2.60^{a}
1.1	17^{a}	3	1.50^{a}
Sole	65^{c}	5	6.30^{c}

*Severity data obtained at 13WAP for both seasons.
**Row arrangements; 2:2 – sesame/maize in alternate pair of rows; 2:1-Alternate pairs of sesame to single row maize; 1:1 – sesame/maize in single alternate r ows; Sole crop – sole sesame. Means within a column of each season followed by same letters are not significantly different at $P \leq 0.05$ according to Duncan's Multiple range test.
Source: Enikuomehin *et al*. (2010)

Table 24 : Agronomic and yield parameters of sesame as influenced by different row arrangements in sesame/maize intercrop in first and second rainy seasons in 2005 at Abeokuta, Nigeria.

Agronomic parameter	*Row arrangement			
	2:2	2:1	1:1	Sole crop
Plant height (m)				
First Season	1.4[a]	1.5[a]	1.6[b]	1.5[a]
Second Season	1.8[b]	1.7[a]	1.8[b]	1.8[b]
Mean	1.6[a]	1.6[a]	1.7[b]	1.7[b]
Capsule number/plant				
First Season	53.0[bc]	61.0[b]	78.7[a]	67.7[ab]
Second Season	158.4[c]	145.5[ab]	187.6[b]	126.7[a]
Mean	105[b]	76.5[c]	133.2[a]	97.2[bc]
Branches/plant				
First Season	3.6a[b]	4.0[a]	4.3[a]	3.3[b]
Second Season	10.7[a]	7.3[b]	7.7[b]	5.3[c]
Mean	7.2[a]	5.6[b]	6.0[ab]	4.3[c]
Seed weight/plant (g)				
First Season	9.3[b]	9.4[b]	11.0[a]	7.9[c]
Second Season	39.2[a]	37.7[a]	42.7[a]	26.7[b]
Mean	24.2[a]	23.5[a]	26.8[a]	17.3[b]
Capsule weight/plant (g)				
First Season	17.9[b]	17.3[bc]	21.1[a]	14.8[c]
Second Season	73.8[a]	68.8[a]	83.7[a]	46.4[c]
Mean	45.8[b]	43.0[b]	52.4[a]	30.6[c]
1000-seed weight (g)				
First Season	2.9[b]	3.1[b]	3.5[a]	2.9[b]
Second Season	3.5[b]	3.4[b]	3.8[a]	3.1[c]
Mean	3.2[bc]	3.3[b]	3.7[a]	3.0[c]
Grain yield (kg/ha)				
First Season	265[b]	243[b]	329[a]	215[c]
Second Season	426[b]	439[a]	478[a]	366[c]
Mean	345[b]	341[b]	404[a]	291[c]

*Row arrangements; 2:2 -sesame/maize in alternate pair of rows; 2:1 – Alternate pairs of sesame to single row maize; 1:1 – sesame/maize in single alternate rows; Sole crop - sole sesame. Means followed by same letters across the rows for each agronomic/yield parameter are not significantly different at $P \leq 0.05$ according to Duncan's multiple range test.
Source: Enikuomehin *et al*. (2010)

Prior to the report of Enikuomehin *et al.* (2010), there was no report on the optimum population density of sesame in a mixed cropping desirable for achieving reduced disease incidence and severity. Hence in a follow-up study, Enikuomehin *et al.* (2011) investigated the effect of population densities of sesame intercropped with maize in 1:1 arrangement on sesame foliar diseases. The study concluded that a sesame population density of 133,333 plants/ha is the most ideal in an intercrop with maize to achieve significantly reduced incidence and severity of Cercospora leaf spot, Alternaria leaf blight, as well as higher grain yield (Tables 25 – 28).

Table 25 : Effect of population density of sesame interc ropped with maize on incidence of Cercospora leaf spot (CLS) disease of sesame in Abeokuta, Nigeria.

Treatment	2006		2007		Pooled Mean	
	Infected leaves (%)	Infected plants (%)	Infected leaves (%)	Infected plants (%)	Infected leaves (%)	Infected plants (%)
Sesame (266,666 plants/ha) + maize	47.2^{bc}	97.4^{ab}	65.5^{b}	97.5^{a}	56.4^{a}	97.5^{a}
Sesame (177,777 plants/ha) + maize	25.51^{c}	92.5^{b}	36.6^{c}	90.5^{b}	30.9^{c}	91.5^{a}
Sesame (133,333 plants/ha) + maize	15.6^{d}	81.2^{c}	21.2^{d}	76.2^{c}	18.4^{d}	78.7^{b}
Sole sesame (266,666 plant/ha)	95.7^{a}	100.0^{a}	81.3^{a}	100.0^{a}	48.5^{b}	100.0^{a}

*Treatment is sesame intercropped with maize in single alternate row (1:1) arrangement.
Data obtained at 12 weeks after planting (WAP) and values along the column with same superscript are not significantly different (P≤0.05) according to Duncan's multiple range test.
Source: Enikuomehin *et al.* (2011)

Table 26 : Effect of population density of sesame intercropped with maize on severity of *Cercospora* leaf spot (CLS) disease of sesame in Abeokuta, Nigeria.

Treatment	2006			2007			Pooled data		
	Lesion number (per ¼ leaf area)	Visual score	Disease rating	Lesion number (per ¼ leaf area)	Visual score	Disease rating	Lesion number (per ¼ leaf area)	Visual score	Disease rating
Sesame (266,666 plants/ha) + maize	18.3^{b}	3	Slight infection	10.5^{b}	3	Slight infection	14.4^{b}	3	Slight infection
Sesame (177,777 plants/ha) + maize	14.0^{c}	2	Trace infection	6.5^{c}	5	Trace infection	10.3^{c}	2	Trace infection
Sesame (133,333 plants/ha) + maize	11.0^{c}	2	Trace infection	4.7^{c}	5	Trace infection	7.9^{c}	2	Trace infection
Sole sesame (266,666 plant/ha)	27.9^{a}	5	Severe infection	18.8^{a}	5	Severe infection	23.4^{a}	5	Severe infection

*Treatment is maize intercropped with sesame in single alternate row (1:1) arrangement.
** Disease rating is from 0-6 scale.
Data obtained at 13 weeks after planting (WAP) and values along the column with same superscript are not significantly different (P≤0.05) according to Duncan's multiple range test
Source: Enikuomehin *et al*. (2011)

Table 27: Effect of population density of sesame intercropped with maize on incidence and severity of *Alternaria leaf blight* (ALB) disease of sesame in Abeokuta, Nigeria.

Treatment	2006			2007			Pooled data		
	Infected plant (%)**	Infected leaves (%)	Lesion size (mm2)	Infected plant (%)**	Infected leaves (%)	Lesion size (mm2)	Infected plant (%)**	Infected leaves (%)	Lesion size (mm2)
Sesame (266,666 plants/ha) + maize	97.3^{b}	13.3^{b}	7.5^{b}	92.9^{b}	5.3^{b}	16.9^{b}	95.1^{a}	9.3^{b}	12.2^{b}
Sesame (177,777 plants/ha) + maize	54.1^{b}	3.8^{c}	6.2^{bc}	81.2^{c}	3.5^{b}	9.2^{c}	67.7^{a}	3.4^{c}	7.7^{bc}
Sesame (133,333 plants/ha) + maize	45.8^{c}	2.5^{c}	4.5^{c}	67.3^{d}	1.8^{b}	2.2^{d}	56.6^{b}	2.4^{c}	3.4^{c}
Sole sesame (266,666 plant/ha)	100.0^{a}	28.1^{a}	14.9^{a}	100.0^{a}	17.2$_{a}$	45.3^{a}	100.0^{a}	22.7^{a}	30.1^{a}

*Treatment is maize intercropped with sesame in single alternate row (1:1) arrangement.
**Indices of disease incidence are infected plants (%) and infected leaves (%) obtained at 12 weeks after planting (WAP); Index of severity is lesion size (mm ^{2}) obtained at 13 WAP.
Values al ong the column with same superscript are not significant different ($P<0.05$) according to Duncan's multiple range test.
Source: Enikuomehin *et al.* (2011)

Table 28: Effect of population density of sesame intercropped with maize on yield and agronomic parameters of sesame in Abeokuta, Nigeria.

Treatment	Plant height (cm)		Grain yield (kg/ha)		Number of branches per Plant		Number of capsules per plant		Seed weight/plant (g)	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Sesame (266,666 plants/ha) + maize	172.9^{b}	178.4^{b}	316.4^{b}	118.3^{d}	1.0^{a}	2.0^{b}	20.7^{b}	28.4^{d}	5.3^{b}	8.3^{c}
Sesame (177,777 plants/ha) + maize	148.2^{c}	174.1^{bc}	327.1^{b}	334.1^{b}	1.0^{a}	5.0^{a}	19.9^{b}	80.1^{b}	5.2^{b}	23.5^{b}
Sesame (133,333 plants/ha) + maize	134.1^{d}	169.3^{c}	621.9^{a}	460.8^{a}	2.0^{a}	7.0^{a}	57.3^{a}	110.3^{a}	3.05^{a}	32.4^{a}
Sole sesame (266,666 plant/ha)	185.4^{a}	204.8^{a}	595.7^{a}	279.8^{a}	3.0^{a}	5.0^{a}	54.2^{a}	68.2^{c}	28.3^{a}	19.7^{b}

Treatment is maize intercropped with sesame in single alternate row (1:1) arrangement.
Values with same superscript along the c olumn are not significantly different at P $\leq$0.05 according to Duncan's multiple range test.
Source: Enikuomehin *et al*. (2011)

7.3.3 Studies on the Combined Effect of Intercropping and Plant Extracts on Plant Disease Management

The successes recorded in the use of either intercropping or plant extract to achieve reduced field diseases and attain higher yields in sesame, prompted the series of research into the complementary effect of both options in sesame disease control. Subsequently, studies were conducted to determine the effect of foliar spray with extracts of *C. odorata* or *T. diversifolia* in a sesame/maize intercrop on the incidence and severity of sesame foliar diseases (Jimoh *et al*., 2016). The results showed that foliar spray of the extracts caused disease incidence to be reduced below what was obtained in unsprayed intercropped plots (Tables 29 – 31).

Table 29: Effect of foliar spray of *Chromolaena odorata* and *Tithonia diversifolia* leaf extracts on incidence of Cercospora leaf spot and Alternaria leaf blight diseases and Defoliation of sesame intercropped with maize.

Treatment	Conc. (%)	Disease incidence (%)		Defoliation (M_d)
(Leaf extract)	(w/v)	M_f - CLS	M_f - ALB	(%)
C. odorata	7.0	48.3 ^{cde}	9.50 ^{bc}	16.4 ^{bed}
	7.5	52.9 ^{cd}	9.45 ^{bc}	13.7 ^{cde}
	8.0	45.8 ^{de}	8.00 ^{c}	14.3 ^{cd}
T. diversifolia	7.0	36.0 ^{ef}	6.30 ^{k}	12.6 ^{def}
	7.5	24.4 ^{f}	5.76 ^{c}	10.5 ^{ef}
	8.0	18.8 ^{g}	4.95 ^{c}	8.7 ^{f}
Distilled water	-	75.0 ^{b}	15.43 ^{bc}	19.1 ^{b}
Sesame + maize (Unsprayed intercrop)	-	62.4 ^{bc}	11.20 ^{bc}	17.5 ^{bc}
Sole sesame	-	93.8 ^{a}	29.45 ^{a}	27.6 ^{a}

Notes: Values are pooled means of early and late season data. Means with the same letter along the column are not significantly different at $p \leq 0.05$ according to Tukey's Studentized Range test. Treatment is maize intercropped with sesame in single alternate row (1:1) arrangement sprayed with leaf extracts at different concentrations.
Mf - CLS – Maximum incidence of Cercospora leaf spot at 12 WAP
Mf - ALB – Maximum incidence of leaf infection by Alternaria leaf blight at 12 WAP
Md – Mean defoliation at 12 WAP
Source: Collated from Jimoh *et al*. (2016)

Table 30: Effect of foliar spray of *Chromolaena odorata* and *Tithonia diversifolia* leaf extract on severity of Cercospora leaf spot and Alternaria leaf blight diseases of sesame intercropped with maize in Ejigbo, Nigeria.

Treatment	Conc. (%)	Severity index		
(Leaf extract)	(w/v)	Lesion no.(1/4 leaf area)	Symptom rating	Lesion size (mm^2)
C. odorata	7.0	24.7 ^{bc}	Slight infection	33.7 ^{b}
	7.5	24.3 ^{bc}	Slight infection	34.3 ^{b}
	8.0	23.5 ^{bc}	Slight infection	12.5 ^{b}
T. diversifolia	7.0	18.0 ^{cd}	Trace infection	10.4 ^{b}
	7.5	12.8 ^{d}	Trace infection	7.0 ^{b}
	8.0	9.9 ^{d}	Trace infection	4.9 ^{b}
Distilled water	-	29.9 ^{b}	Severe infection	62.3 ^{b}
Sesame + maize (Unsprayed intercrop)	-	18.3 ^{cd}	Moderate infection	13.4 ^{b}
Sole sesame	-	41.2 ^{a}	Very severe infection	154.7 ^{a}

Notes: Lesion number and symptom rating are severity indices for CLS while lesion size is severity index for ALB. All data are pooled means from early and late seasons obtained at 13 WAP. Means with same letter along the column are not significantly different at $p \leq 0.05$ according to Tukey's Studentized Range test. Maize and sesame intercrop is in alternate row (1:1) arrangement.
Source: Collated from Jimoh *et al*. (2016)

This impact was highest from *T. diversifolia* extract at 8.0% (w/v). Similarly, grain yield, incidence of normal seeds, seed viability and reduced defoliation were enhanced by foliar spray of *T. diversifolia* or *C. odorata* extract in sesame/maize intercrop (Table 31). As a follow up to these observations, further studies were undertaken to determine the number of times that the foliar spray of *T. diversifolia* extract is required to achieve optimal disease management and crop yield in a sesame/maize intercrop. This study was necessary because the fewer the frequency of foliar spray, the more adoptable is the method for the farmer. The results obtained showed that a three spray regime of 7.5% (w/v) of *T. diversifolia* enhanced the most favourable outcome in respect of reduced disease incidence, severity, defoliation and seed infection. It also increased grain yield and incidence of normal seeds. The effect of 3-spray regime of *T. diversifolia* was comparable to that obtained from the application of synthetic fungicide (Carbendazim 50% wp) (Tables 32 and 33).

Table 31: Effect of foliar spray of *Chromolaena odorata* and *Tithonia diversifolia* leaf extracts on grain yield, incidence of normal seeds, seed viability and post-harvest fungal infection of seeds of sesame intercropped with maize in Ejigbo, Nigeria.

Treatment (Leaf extract)	Conc %(w/v)	Grain yield/plant (g)	Seed incidence (%)		Seed germination (%)	Fungal Infection (%)
			Normal	Abnormal		
C. odorata	7	372.5^{abc}	84.3^{b}	15.6^{cd}	87.6^{bc}	12.3^{cd}
	7.5	461.0^{bc}	87.2^{bc}	12.7^{de}	89.3^{bc}	10.6^{cd}
	8	529.0^{a}	80.6^{d}	16.0^{cd}	90.6^{ab}	9.3^{cde}
T. diversifolia	7	296.3^{bc}	84.5^{cd}	15.5^{cd}	94.6^{ab}	5.3^{de}
	7.5	325.1^{bc}	90.3^{ab}	9.6^{ef}	96.6^{ab}	7.0^{cde}
	8	425.3^{bc}	93.1^{a}	6.7^{f}	98.0^{a}	2.0^{e}
Distilled water		268.5^{c}	74.9^{e}	25.0^{b}	75.0^{d}	25.0^{b}
Sesame + Water		334.1^{bc}	80.5^{d}	19.5^{bc}	85.0^{c}	15.0^{c}
Sole Sesame		384.1^{abc}	57.9^{f}	42.0^{a}	50.3^{e}	49.6^{a}

Means with same letter along with column are not significantly different at P <0.05 according to Turkey's Studentized Range Test. Values are means of two (early and late) seasons .
Source: Jimoh *et al*. (2016).

Table 32 : Effect of frequency of application of *Tithonia diversifolia* leaf extract on incidence of Alternaria leaf blight, Cercospora leaf spot and leaf defoliation of sesame in sesame/maize intercrop during early and late cropping seasons in Ejigbo, Nigeria.

		Incidence (ALB) %	Incidence (CLS)%	Leaf Defoliation (%)
One-spray regime	7.0	14.14b	70.02b	14.5b
	7.5	10.90bcde	55.89bcde	13.3bc
	8.0	9.89bcde	55.83bcde	14.5b
Two-spray regime	7.0	12.72bcd	67.41bc	14.5b
	7.5	10.43bcde	52.99cdef	12.3bc
	8.0	7.22bcde	57.55bcdef	10.2bc
Three-spray regime	7.0	8.86bcde	63.60bcd	13.3bc
	7.5	3.94e	40.13ef	8.8c
	8.0	4.77de	40.04ef	10.5bc
Carbendazim (50%WP)		6.60cde	39.77ef	9.3c
Sesame/Maize (Unsprayed intercrop)		12.20bcd	67.61bc	12.8bc
Sole Sesame		31.27a	96.0a	26.7a

Means with the same lett er along the column are not significantly different at $P < 0.05$ according to Tukey's Studentized Range Test. Data are means of early and late seasons.
Early Season: June – September, 2011; Late Season: August – November, 2011.
ALB Incidence: Maximum incidence of leaf infected (%) by Alternaria leaf blight at 12WAP
CLS Inidence: Maximum incidence of leaf infected (%) by Cercospora leaf spot at 12WAP.
Leaf Defoliation: Maximum leaf defoliation at 12WAP.
Source: Jimoh *et al.* (2021).

Table 33: Effect of frequency of application *Tithonia diversifolia* leaf extract on the severity of Cercospora leaf spot and Alternaria leaf blight diseases of sesame intercropped with maize during early and late cropping seasons in Ejigbo, Nigeria

Treatment (Frequency of Application of Plant extract)	Conc. % (w/v)	Severity Index*	
		CLS Lesion number($_1/_4$ leaf area)	ALB Lesion size (mm^2)
One-spray regime	7	17.81abc	15.4b
	7.5	12.46bcde	14.1b
	8	14.12bcd	17.3b
Two-spray regime	7	17.85abc	18.2b
	7.5	13.43bcde	10.0b
	8	10.88cde	16.1b
Three-spray regime	7	14.88cdef	14.9b
	7.5	7.21ef	4.2c
	8	7.87ef	6.2c
Carbendazim (50%WP)		6.95f	4.0c
Sesame/Maize (Unsprayed intercrop)		15.89bc	16.3b
Sole Sesame		24.91a	96.0a

Means with the same letter along the column are no t significantly different at $P < 0.05$ according to Tukey's Studentized Range Test. Data are means of early and late seasons.
Early Season: June – September, 2011; Late Season: August – November, 2011.
*Severity index obtained at 13WAP.
Source: Jimoh *et al*. (2021)

The summary of all these reports is that the endowments of nature such as intercropping or foliar application of plant extracts are effective plant disease management options. The combination of these two options gives a better outcome and would not necessarily demand unaffordable inputs from a resource-limited farmer. The advantage of the combined approach includes the low cost, familiarity of the farmer with these options, environment friendly nature as well as the ease of procurement and preparation of necessary inputs. Indeed, the average farmer requires little or no special training to exploit the God-given endowments of nature.

8.0 FUTURE RESEARCH OUTLOOK AND ENVIRONMENTAL CONCERNS

In view of the damning effects of global warming, research in every area of specialisation should pay particular attention to how

to ameliorate the effects of global warming and environmental degradation. In plant disease management, the use of the endowments of nature requires to be optimised to safeguard the plant health as well as preserve the delicate elements of nature. For example, sawdust of tropical tree species have become environmental nuisance in most of the cities in South-west Nigeria. Saw mills are filled with heaps that are usually incinerated in the open causing pollution and aggravating the global warning.

The fact that products of tropical tree species have been known to have antifungal properties, as well as the need to safeguard the environment incited my recent foray into the prospects of antifungal potentials inherent in saw dusts of tropical plants in plant disease management. Preliminary results have shown that saw dust and saw dust extracts of some tropical trees have potential to reduce the progression of some plant diseases. Notable among these are saw dust and saw dust extract of *Cola nitida, Gmelina aborea* and *Anogeissus leiocarpus*.

The use of fermented extract from leaf or bark of tropical plants also received attention in recent years. A number of my Postgraduate students have been working on this and the preliminary results have been very encouraging. The gains from these is that the answer to plants afflictions lie within the plants and the environment where the plants live. The task before Man therefore, is to bring his God-given ingenuity to bear and to draw out the best from these treasures of nature. This is what I have been striving at in all my research life.

9.0 HUMAN CAPITAL DEVELOPMENT AND UNIVERSITY SERVICES

9.1 *Human Capital Development*

The array of contributions that I have enumerated in this lecture have been with the active involvement of my undergraduate and postgraduate students. By this, I have had the privilege of investing in the development of human minds. In particular, I have

successfully supervised, as Major Supervisor, a total of Five (5) Ph. D and Eleven (11) Master's degree students. Eight (8) others are currently in training (Table 34). I have also been Co-supervisor of over Twenty (20) other postgraduate students till date. The outcome of the research work of some of these students have been cited in this lecture. I am proud of these individuals, whose accomplishments have always been the 'Teacher's reward here on earth'.

TABLE 34: POSTGRADUATE STUDENTS SUPERVISED TILL DATE

S/N	NAME	DEGREE	YEAR OF GRADUATION
A	*M. AGRIC CROP PROTECTION*		
1	Adeagbo, E. O. (Now Mrs. Oyedeji)	M. Agric	2008
2	Aduwo, A. M.	M. Agric	2008
3	Afolagboye, M.F.	M. Agric	2011
4	Jimoh, Muideen	M. Agric	2011
5	Odusami, O. (Now Mrs. Oduwaye)	M. Agric	2011
6	Egbontan, A. O.	M. Agric	2014
7	Bodunde R. O. (Now Mrs Onafuwa)	M. Agric	2016
8	Ngegba, P. M. (Foreign student)	M. Agric	2016
9	Afolabi, T. A.	M. Agric	2019
10	Adeyemi, O.	M. Agric	2019
11	Adeniyi, B. J.	M. Agric	2019
12	Obafemi; A. E.	M. Agric	(In progress)
13	Adeeko, I. O. (Mrs.)	M. Agric	(In progress)
14	Olabimtan, Abiodun O.	M. Agric	(In progress)
15	Coker, K.O. (Miss)	M. Agric	(In progress)
B	*PH.D PLANT PATHOLOGY*		
1	Otusanya, M.O. Dr. (Ms.)	Ph.D	2016
2	Oyedeji, E.O. Dr. (Mrs.)	Ph.D	2019
3	Falade, M.O. Dr.	Ph.D	2019
4	Beckley F. Dr. (Mrs.)	Ph.D	2019
5	Egbontan, A.O. Dr.	Ph.D	2019
6	*Jimoh Muideen (Deceased)	Ph.D	
7	Otunoye, A.	Ph.D	(In progress)
8	Fashola, O.	Ph.D	(In progress)
9	Oduwaye, O. (Mrs.)	Ph.D	(In progress)
10	Adesegun, E. A. (Mrs.)	Ph.D	(In progress)

*Died on December 12, 2012 before thesis defence

9.2 University services

My entire life right from conception has been a hallmark of God's grace. For example, I was invited by Prof. T. O. Tayo to send in an application for job at University of Agriculture, Abeokuta (UNAAB) (then) without ever knowing a vacancy existed. Meanwhile, I needed a job then and was so financially indisposed that if I was requested to bring more than one copy of my *Curriculum Vitae* (CV) and credentials, I would not have attended the interview. Behold, at the interview, the system had made about 25 copies of my CV and credentials for panel members and all I had to do was answer questions. Suffice to note that the panel, in my view then, was too loaded for an applicant for the post of an Assistant Lecturer! Meanwhile, that was the UNAAB of our founding fathers.

On assumption of duty on July 24 1994, I started another round of experience of God's goodness. The people and the system have been kind to me. The system provided me with opportunities to learn, grow and serve. I have had the grace to serve the University as Chairman, ASUU- UNAAB (2002 – 2004); Deputy Dean, COLPLANT (August 2004 – July 31, 2005); Ag. Head, Department of Crop Protection (August 1, 2005 – July 31, 2007); Congregation Representative in the Governing Council (February 2011 – January 2014); Dean, Postgraduate School (August 1, 2012 – January 6, 2016); Chairperson, Committee of Deans & Directors (CODAD) (August 1, 2016 – January 6, 2017); Deputy Vice Chancellor (Development) (January 6, 2016 – May 23, 2017) and Ag. Vice Chancellor (May 24, 2017 – October 30, 2017).
By these, I conclude that God has been so kind and good to me, and I owe him to 'Love Him and my neighbours as myself'. I trust God to continue to help me in this regard.

10.0 CONCLUSIONS

The panacea to plant afflictions lie within the plant and its surroundings. Plant-based resources such as crude or fermented

extracts and ash, ecosystem management practises like intercropping, plant population density and planting arrangements have been verified to protect plants from fungal diseases. This inherent potential of nature to keep its balance may explain how the plant kingdom have survived the raging assault of plant pathogens over the ages. Furthermore, tropical agriculture and in particular, farming in resource-limited communities have survived on the crest of the potential of plants and nature to strike a balance against diseases and pests.

A missing link in the quest to utilise the endowments of nature in plant disease management, however, is the information gap that currently exists between researchers and the indigenous farmers in the various farming systems. The farmer's indigenous knowledge of the different plants and their potentials as well as the peculiarity of the respective ecosystem is very important in developing efficient crop protection strategies. Therefore, a renewed effort is necessary to engage farmer's indigenous knowledge in the bid to unravel and exploit the hidden potentials of nature for improved crop protection.

11.0 RECOMMENDATIONS

1. There are numerous research findings on the efficacy of different plant products and environment-friendly practices in the management of fungi-induced diseases of tropical crops. These findings require to be harnessed into a compendium for easy reference. This is important because of the inherent value of these information for the development of crop protection strategies in tropical farming systems.
2. Plant products and environment-based protection practices should be given more emphasis by researchers and policy makers as a way of reducing the cost of crop production. Indeed, the time is due for a Plant Protection Policy in Nigeria.

3. Increased attention and fund allocation to research in the use of plant and environment-based strategies will achieve among others, the following:
    i. Research findings can be fully developed to the point of adoption and use in large scale farming,
    ii. creation of jobs through employment in industries set up to produce plant-based remedies on large scale,
    iii. provision of effective and efficient alternatives to synthetic chemicals,
    iv. enhancement of general interest in the value of crop protection and plant health management as well as growth in stakeholder-participation in the crop protection enterprise.
4. The Federal Universities of Agriculture and the National Agricultural Research Institutes (NARIs) should be further strengthened and funded to contribute more to Plant Protection in Nigeria.
5. Further research into other viable plant products and environment-based crop protection practices should start from the rural farmers. These people still have indigenous knowledge that require to be tapped. By this, the treasures of knowledge hidden in the farmer and the endowments of nature will become available to future generations to live by.

12. 0 ACKNOWLEDGMENTS

I give thanks to God, the Creator of the heaven and earth for my conception and birth and then, re-birth in Christ Jesus. This new birth is the definition of my essence and the basis of my appreciation to God today. I thank God for the grace to present this lecture. To Him be all glory and honour in Jesus name, Amen.
I thank my parents who gave me birth; His Royal Majesty, Late

Oba Robert Adeduro Enikuomehin JP and Olori Grace Aduke Enikuomehin. They gave me and my siblings all the care and support we needed to grow up to become what we are today. Words are definitely not enough to express my appreciation to my parents who gave everything they could muster to ensure I was well brought up and schooled. I thank God that my mother is still alive to witness this occasion.

Like I mentioned earlier, the grace of God brought me to UNAAB (as it was called then) to start a career that has been a blessing. Therefore, I wish to acknowledge the Federal University of Agriculture, Abeokuta (FUNAAB) for providing me with the avenue to be who I am today.

Vice Chancellor Sir, permit me to thank you and your predecessors for the sacrifices that have been variously deployed to make FUNAAB, the beacon of our fatherland. For the records, I wish to thank Prof. 'Nimbe Adedipe (pioneer VC) and others namely, Emeritus Prof. Julius Okojie, Late Emeritus Prof. Israel Adu, Prof. Ishola Adamson, Prof. Olufemi Balogun, Prof. Bandele Oyewole and Prof. Felix Salako. I have the privilege of working under all the Vice Chancellors in various capacities, all for which I am very thankful.

I acknowledge with appreciation, the labours of the former Deputy Vice Chancellors namely: Prof. T. O. Tayo, Prof. A.R.T. Solarin, Prof. S.T.O. Lagoke, Prof. O.J. Ariyo, Prof. I.C. Eromosele, Prof. T.O. Arowolo, Prof. C.F.I. Onwuka, Prof. Waheed Adekojo, Prof (Mrs.) O. Eromosele, Prof. (Mrs.) M. Dipeolu, Prof. L.O. Sanni, Prof. C. O. Adeofun and Prof. (Mrs.) B.I. Akeredolu-Ale. In the same light, I acknowledge the current Principal Officers of the University, all with whom I have a worthy relationship; Prof. O. B. Kehinde (Ag. VC), Prof. C. O. N. Ikeobi (DVCA), Dr. A. Adekola (Registrar), Mr. Chukwunwike Ezekpeazu (Bursar) and Prof. (Mrs.) Fehintola Onifade (University Librarian). I thank you all

for your commitments to this University. I also find it duty bound to thank the former Principal Officers of this University who were part of my growth in various ways; Dr. T.M. Salisu, Dr. A. Agboola, Dr (Mrs.) M.O. Salaam (former University Librarians), Omo Oba 'Bisi Shoboyejo, Mr. Ademola Oyerinde,, Dr. M.O. Ayoola (former Registrars), Late Mr. 'Leke Adeboye, Mrs C. I. Kuforiji, Late Mr. Femi Ogini, Dr. (Mrs) L. O. Onwuka (former Acting Registrars), Late Mr. Ajayi and Mr. M.O. Ilesanmi (former Bursars).

The Senate and Congregation of the University provided me with the opportunity to learn and serve. I therefore thank everyone (too numerous to mention) who were and are still part of my life through these important University bodies.

In the course of my journey in the University system, some people were positioned as my teachers and mentors. In this regard, I wish to acknowledge them for their efforts towards my progress. From the University of Ibadan, I thank Emeritus Professor 'Tunde Ikotun (my Ph. D supervisor) who accepted to add me to his long list of Ph. D. students when I became 'orphaned' by the sojourn of my erstwhile supervisor to Zimbabwe for sabbatical placement and leave of absence. I also thank Late Prof. E.J.A. Ekpo (my M.Sc. supervisor) as well as Professors F.K. Ewete, B. Fawole, G.I. Atiri and I. Fawole for the tutelage and care I received during and after my postgraduate training. From FUNAAB, I acknowledge and duly appreciate the contributions and commitments of Professors T.O. Tayo, T. A. O. Ladeinde, M.T. Adetunji, O. J. Ariyo, F.O. Olasantan, E. B. Otesile, C.F. Mafiana, M.S. Ayodele, S. O. Oluwalana, T.O.S. Popoola, G. O. Olatunde and F.O. Bamiro. I also thank Prof Steve and Prof (Mrs.) C. Afolami, Professors C.F.I. Onwuka, I.C. Eromosele, I.O.O. Aiyelaagbe, J.G. Bodunde, Prof (Mrs) F. O. Henshaw, Emeritus Professor Ayoka O. Adebambo, Late Professors P.A. Okuneye, A. Y.A. Adeoti, K.A. Okeleye and K.A. Elemo. No doubts, there are

still others I may have inadvertently left out, and to all I say 'Thank you'.

Vice Chancellor Sir, I once had the rare privilege to serve as Acting Vice Chancellor of this University for a period of five months. During this period, I was responsible to and for everyone in this system. I wish to use this opportunity to thank the entire University community for the cooperation I enjoyed in the task I undertook. In particular, I thank the Pro-Chancellor and Chairman of the Governing Council Bar. (Dr.) Aboki Zhawa and the members of the Governing Council for their support and assistance. I also wish to acknowledge the executive and members of the Unions: ASUU, SSANU, NASU and NAAT for their collaborations with me. In a unique way, I had a team of Principal Officers to which I owe a debt of gratitude. I, therefore, acknowledge the following individuals for their commitments and sacrifices: Prof (Mrs.) C.O. Eromosele (DVCA), Dr. (Mrs.) L. O. Onwuka (Ag. Registrar) Mrs. C. O. Oyewunmi (Ag. Bursar) and Dr. (Mrs.) Mulikat Salaam (University Librarian). I also wish to thank Mrs. O. Dawodu (Director, VCO), and other staff of the Vice Chancellor's office including Mrs. O. G. Daramola, Mr. Godday Odigie, Mr. M. S. Adeogun, Mr. A. O. Ogundele, Mr. Ajani Olagun, Mr. Gabriel Oredipe, among others.

Eight years after my assumption of duty as an academic staff in this University, I got saddled with what I consider the first major challenge at giving leadership. I was elected the Chairman of my union, ASUU-UNAAB. Besides the opportunity it afforded me to serve, it also helped me to learn the rudiments of union principles, strategies and discipline as well as human resource management, all of which became useful in my later years of service in the University. I, therefore, wish to thank ASUU-UNAAB for this opportunity and to appreciate everyone that was part of the task then. Please permit me to single out for mention the following individuals (titled as they then were); Dr. Biodun Onilude (Zonal Co-ordinator and GOC – Ibadan Zone), Dr. 'Kayode Bamgbose,

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By the grace of God, I belong to the College of Plant Science and Crop Production. I am no doubt a product of the disciplined COLPLANT culture. Since a culture is only discernable through the human interaction it fosters, I therefore wish to thank the entire members (past and present) of the COLPLANT family for their roles in providing an enabling environment for me to thrive. I thank you all, but permit me to mention Prof. (Mrs.) M.A. Ayo-Vaughan and Dr. Clara Oyegoke who graciously shared their office with me and my friends on assumption of duty in 1994. I also thank Profs. Akeem Oyekanmi, Francis Sowemimo, 'Wale Salau,'Tayo Makinde, Sunday Adigbo, David Ojo, Olusegun Olubode, Oluwatoyin Babalola, Jamiu Azeez, 'Bola Senjobi, Chris Adejuyigbe, Raphael Adeyemi, Tom Fabunmi, Christopher Alake, Lateef Hammed (Deputy Dean), Drs. Pius Akintokun, Segun Oduwaye, Julius Amira, Dr (Mrs) F. A. Olowokere, among others. Vice Chancellor Sir, when I resumed duty in 1994, this profession wasn't rosy at all. Indeed, not many Ph.D. holders would want to enlist on this job. Thank God for the successes of ASUU struggles. Therefore, the presence of a few close allies made it possible to start off. In this regard, I wish to acknowledge the roles of Prof. Tunde and Prof. (Mrs.) Iyabo Kehinde in providing a launching

pad for the young Ph.D holder who just came to town with nothing but a small school bag. I also acknowledge the assistance and friendship of Prof. M. O. Atayese and his wife, Dr. (Mrs.) Bisi Atayese. The trio of Atayese (Murphy), Kehinde and Enikuomehin were the legendary "Murphy group" of COLPLANT, the impact of which could only be remembered by those present at that time. Prof. Tunde and Prof. (Mrs.) Funmi Idowu also played very significant roles in helping me to settle down. I recall the sumptuous meals that I often got invited to share in their home. I thank you all.

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In the University, I have been involved with a large number of people across all divides. It is, therefore, a herculean task that becomes impossible by reasons of time and space to mention everyone. To all I express my appreciation for all the forms of relationship I have been involved in. However, I wish to mention Prof. and Prof. (Mrs) Lawrence Arogundade, Prof. Adewale and Prof (Mrs) Morenike Dipeolu, Prof. and Prof. (Mrs) L. O. Sanni, Prof. and Dr. (Mrs) G. A. Dedeke, Professors Wilfred Alegbeleye, C. O. Adeofun, Sheriff Adewuyi, W. A. O. Afolabi, J. O. Oguntuase, J. K. Adewumi, Muraina Olayanju, M. O. Arigbede, J. Olanite, Kola Adebayo, Helen Bodunde, Bosede Sotiloye, 'Ronke Akintokun, C. O. N. Ikeobi, M. O. Ozoje, Tumi Adebambo, Enitan Fapojuwo, Bolaji Omemu, Petra AbduSalam – Saghir, Abdul-Rasak Adebowale, Drs. M. Ogunjobi, Dapo Fapetu, F. T. Ibrahalu, Mr. 'Biodun and Dr. (Mrs.) 'Funke Akinbule. I also thank

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Vice Chancellor Sir, in the Department of Crop Protection which is my home base, I wish to acknowledge and thank all members of staff and students (current and past) for assistance and co-operation extended to me. In particular, I thank Dr. C. G. Afolabi (my Ag. Head of Department), Professors S. O. Afolami, J. J. Atungwu, O. R. Pitan, A. R. Popoola, Emily Ayo-John, 'Bola Osipitan, Drs. I. S. Odeyemi, I. A. Aderolu, O. T. H. Hamzat (Mrs), C. Filani (Mrs), Sam Orisajo, Olufemi Oyelakin, Mrs Olaide Bolarinwa, Mr. Stanley Okwara, Mr. R. O. Coker and Mr. J. Onaolapo. No doubt, the harmonious relationship in the Department of Crop Protection enhanced my productivity over the years. I wish to plead that we all work to sustain this.
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In 2017, I was honoured with the Fellowship of the Nigerian Society of Plant Protection, a society that also provided the

opportunity for me to serve as Editor-in-Chief of the Society's Journal for four years. The Society, being the rallying point of Plant Protection specialists in Nigeria deserves mention at this forum. I, therefore, thank the Society for the contributions it has made to my intellectual and professional development and do wish to also personalize my gratitude to Prof. D. B. Olufolaji (Chairman, BOT), Prof. J. J. Atungwu (President) and Prof. (Mrs.) Funmi Alabi (Immediate Past President), among others. Prof. O. R. Pitan, and Prof. A. A. Osipitan are two good and true friends of mine from the 1990s till now. I seize this opportunity to thank both of them for their warm and faithful friendship. I thank Professor Helen Bodunde (Chairperson, Publications Committee) and others members for their contributions to the improvement of the quality of the manuscript of this lecture.

During my years of postgraduate training at the University of Ibadan, I found friends that helped to shape the course of my social, intellectual and in part, spiritual growth. The names of Professors 'Bayo Omoloye, Sam Bankole, Femi Pitan, Charles Onunuju, Funke Adekunle, Dr. Abiodun Joda and Dr. Janet Edeme readily come to mind. I thank you all.

I resumed my undergraduate study at the Bendel State University (now Ambrose Alli University), Ekpoma at the age of 17 years. It was a unique experience for me because the environment was different from where I grew up. Different in terms of the social and cultural orientation and hence the need for me to grow faster than the pace I had anticipated. However, it did not cost me anything unusual to settle down and adjust to the fast pace of everything because the people were nice and accommodating. I, therefore, owe a debt of gratitude to the staff and students that made my undergraduate years a strong foundation for my later years. In this regard, I thank my lecturers: Late Dr. F.O. Aderungboye and his family, Late Dr. S.A. Emua, Prof. E.O. Okoegwale, Dr. Y.Y. Karatela (from India), Dr. (Mrs.) V.U. Aiboni and Miss Gladys

Ibezim (as she was then). These lecturers taught with dedication which I still find uncommon till date. I also reckon with and appreciate the friendship of my school mates: Mr. Sam Ajibade, Mrs Bola Ajisola (Nee Adekugbe), Ms. Agatha Asiedu, Prof Fred Esumeh, Rev. (Dr.) O. Egerton-Otumu, Prof. Joel Agbolagba, Prof. Ben Obadoni, Drs. Victor Ekun, Dan Eseigbe, Clarence Maku-Kemi, Sylvester Aigbe, Tony Obar, Humphrey Ehigiator, Timothy Esekhaide, Dr (Mrs) Ugbogu (nee Omokafe) and Late Esekhaigbe Anegbe.

Vice Chancellor Sir, the memory of my childhood days remains pleasant to me. This is because I enjoyed the safety of a well-knitted home with my siblings in tow and a retinue of close friends who shared similar passions, interest and aspirations under the tutelage of parents that were available. I recall with appreciation the friendship of Dr. Jide Aiyenimelo, Barr.James Tomomewo, Professor Olukoya Ogen (Immediate Past Provost, Adeyemi College of Education, Ondo), Late Olayemi Ogungbemi (who introduced me to my wife), Mr. Ayo Arowojolu, Barr. Segun Arowoyele, Messers Wole Akinseloyin, Bodunrin Ogunbameru, Nelson Olokungbemi, Segun Oritunmise and Gbenga Akinmoju. With their spouses, these wonderful people have remained my close friends till date and for this, I specially thank you all. I also acknowledge my colleagues, the members of Stella Maris College, Okitipupa, 1982 set. The recent effort at keeping closer has been a nice reminder of those days. I thank you all. Please pardon my inability to accommodate the long list of the membership here.

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I thank my neighbours in Obantoko-Abeokuta where I live; Prof and Deaconess O. Olasantan, Dr. and Mrs. Femi Akinbile, Alhaji and Alhaja Olaosebikan Kehinde, Chief and Mrs. 'Niyi Adekunle, Mr. and Mrs. Martins, Mr. and Mrs. K. Omidiji, Mr. and Mrs. Peter Okuboye are my immediate neighbours in Akinbile close. I appreciate you for your efforts at making me enjoy the environment and for being peace-loving neighbours. I also thank Prof. and Mrs O. J. Ariyo as well as the executive and members of the Ifelodun – Arokoje Community Development Association, Obantoko – Abeokuta: Pastor E.K. Oso, Engr Taiwo, Prof. Austin Adebayo, Dr. Tomori Oluwunmi, Mr. Jamiu Odunjo and others too numerous to mention.

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I am a born – again Christian whose Christian walk has been helped by the unhindered access to God's Word and spiritual tutelage that I received from the body of Christ. Rock Foundation Church, Abeokuta is my spiritual home and I wish to acknowledge and thank Rev. Tunde and Rev. (Mrs.) Kemi Amosun, Senior Pastor and Assistant Senior Pastor respectively for helping me to grow in Christ. I joined the church sometimes in 1996, a few months after giving my life to Christ. It was at the invitation of Dr. Tunde Kehinde (as he then was) and my life has never been the same. I thank God for the grace to find this House of God to grow and in which to serve Him.

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Ogunkunle, Engr and Mrs. Adebiyi, Mrs. Funmi Salisu, Mr. and Mrs. 'Sola Williams, Mr. and Mrs. Dare soyombo, Dr. and Mrs. Charles Erinle, Engr. Kayode Adedigba and all members of 'The Commissioners'. I also thank Dr. and Prof. (Mrs) Olusola Sogebi, Prof. and Dr. (Mrs) Tola Ajadi, Bro. Ben. and Mrs. Biola Oluwapelumi, Dr. and Dr. (Mrs) Olusola Adeleye, Mr. and Mrs. Tito Adeogun, Mr. Idowu Korede, Mr. and Mrs. Biodun Adewale, Mr and Mrs. Gbenga Idowu , Mr. and Mrs. Emmanuel Uchi, Mr. and Mrs. Emman Ogbaola, Engr. and Mrs. Niyi Adesemowo, Mr. and Mrs. Sanmi Aladeyelu, Mr. and Mrs. Ayo Bayewu, Mr. and Mrs. Sunkanmi Opaleye, Dr. and Mrs. Jide Odebiyi and others too numerous to mention. Indeed, the privilege of preaching in this church also makes me a part of everyone and vice versa. Therefore, I thank everyone again and do plead that you pardon the limitations of space and time by which I am unable to list everybody's name. I am confident that Christ reckons with your labour of love. Thank you all.

Vice Chancellor Sir, permit me to acknowledge my siblings. I had made references to their place in my life earlier and I wish to note that words are not sufficient to describe their roles in my life. We grew up together and shared the leanness and bounties of the different stages of life as they came. We influenced each other, mostly for good and shared both our painful and joyous moments together. My accomplishments is their joy and pride just as theirs is mine too. I, therefore, thank Prince and Mrs. Johnson Enikuomehin, Late Dr. Akin Enikuomehin and family, Hon. Tolulope and Princess Olufunke Adewumi, Prince Simbo and Mrs. Sola Enikuomehin, Late Prince Oluwole and Mrs. Ejiro Enikuomehin, Hon. Justice Ademola and Dr. (Mrs.) Adenike Enikuomehin, Prince Ademiju and Mrs. Ileola Enikuomehin, Prof. 'Toyin and Mrs. 'Debby Enikuomehin, Prince and Mrs. Olalekan Enikuomehin and Prince Segun Enikuomehin. All of these family members have contributed significantly to my life and my immediate family. For example, I may not have proceeded to study

for Ph.D in 1991 but for 'Demola's influence. He accused me of being afraid of the Ph.D programme because I had refused to go back to school after the Master's degree. I wanted to work and earn some money while everybody felt otherwise. After two weeks of persuasion, he confronted me with the accusation of hiding my fear of the Ph.D programme under the pretense of wanting a job. To prove him wrong, I took the challenge and proceeded to register for Ph.D the next day. Old boy, thank you!

Mr. Acting Vice Chancellor Sir, distinguished ladies and gentlemen, God's mercy on me also manifested in granting to me the grace to have a peaceful home. God blessed me with a wife that is indeed a helper suitable for me. I, therefore, acknowledge with profound admiration, gratitude and joy, my wife Mrs. Idowu Olujoke Enikuomehin. She accepted to marry me when things were very lean and she has consistently been there to assist me to be this man standing before you! I thank you, Darling. I believe in God that your latter days will no doubt be more glorious than the former. With my wife, God granted to me, the grace of three children, Dr. James Morounfoluwa Enikuomehin, Miss Favour Iyunade Enikuomehin and Mr. Reward Adeoluwa Enikuomehin. All of you have been wonderful and I dare to say, in Him you are going to and will attain your destined heights in Jesus name, Amen. Thank you for making parenting a pleasant experience for us.
To all present here, I thank you sincerely for the honour of your presence. Thank you for coming and for the patience to listen to my story.

Ag. Vice Chancellor Sir, distinguished Ladies and Gentlemen, Thank you and God bless.

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