FEDERAL UNIVERSITY OF TECHNOLOGY MINNA

"FUNGI AND MANKIND: FOR BETTER OR WORSE, NO RETREAT, NO SURRENDER".

BY:

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INAUGURAL LECTURE SERIES 110TH

1ST AUGUST, 2024

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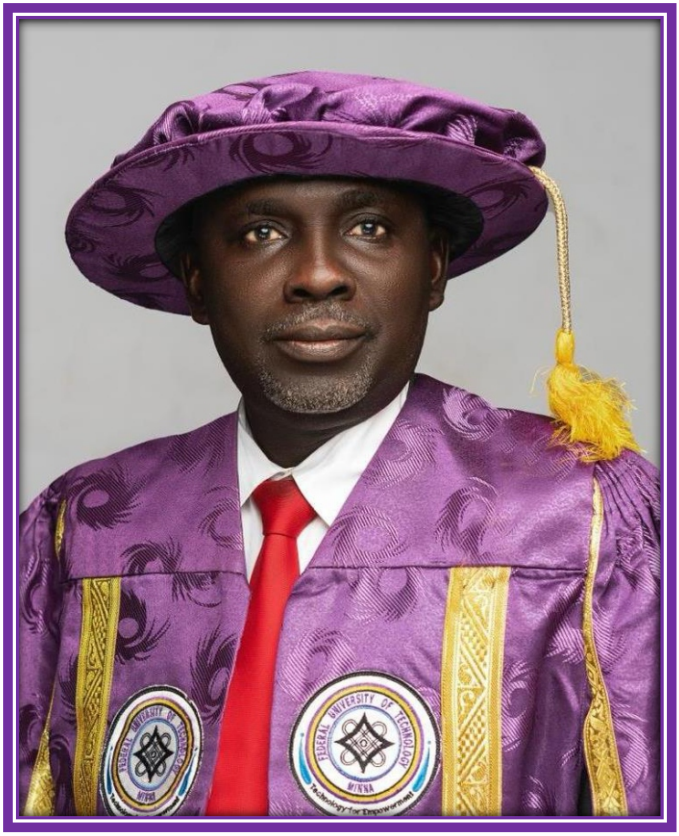

PROF. FARUK ADAMU KUTA

B.Sc. (UDUS), M.Tech. (FUTMIN), PhD (ATBU)

Vice-Chancellor

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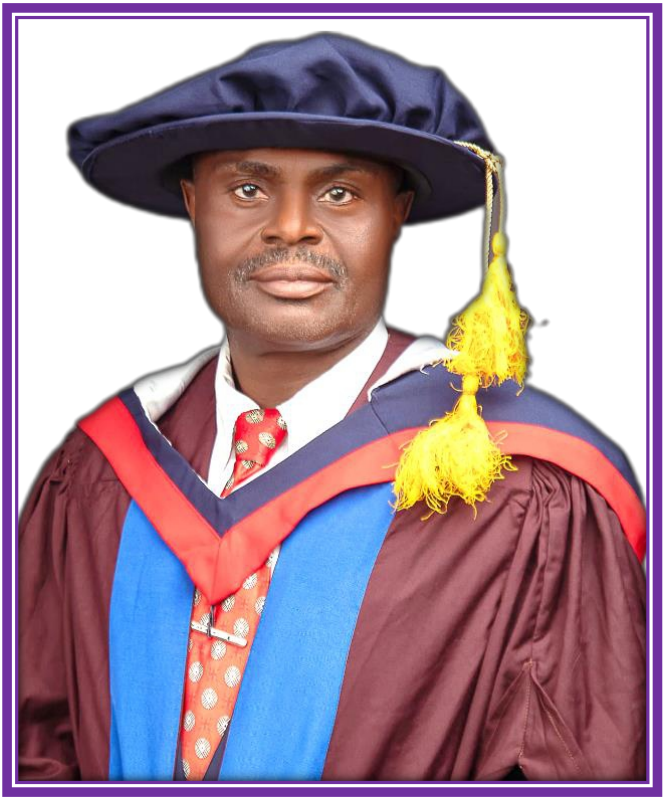

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PREAMBLE

Give praise to the Lord, proclaim his name,

make known among the nations what he has done (Psalm105:1)

Providence charted my academic career right from the very beginning to this level; hence, it is with total humility and immense gratitude to the most High God that I stand before this august assembly today to deliver this inaugural lecture, the 110 in the series.

Mr. Vice-Chancellor Sir, the inaugural lecture is an occasion that provides a platform for a professor to inform colleagues, the campus community and the general public about his contribution to knowledge in his area of specialisation, including current research and plans. Therefore, I have decided to x-ray my research trajectory to date carefully, spanning over two decades commencing from Ekiti State University, Kwara State Colleges of Education, Ado Ekiti, Oro and Ilorin centres, to my academic sojourn at Ibrahim Badamasi Babangida University, Faculty of Sciences, Department of Biological Sciences, Lapai, Niger State Nigeria, to my current University(Federal University of Technology), School of Life Sciences, Department of Plant Biology, Minna, where I attained professional maturity and became the second Professor and first Head of Department. Based on the experience garnered over these years across variegated academic climes, I have chosen to speak on the topic which aptly describes the nucleus of my academic voyage, "Fungi and Mankind": For better or worse: No retreat, No surrender. Therefore, I will try to pay tribute to the past, a moment in the present and openness to the future.

Mr Chairman Sir, about 28 years ago, precisely 17th December 1994, l made a marriage vow, a strong bond, "for better or worse" with my damsel wife Christiana Oluwatoyin Adunni Adebola nee Adewuyi at Baptist Church Ijara-Isin, Kwara State, Nigeria. The marriage is still

very viable, enviable and blessed. This is to let you know that l understood and have practical experience with the topic tenet that l am presenting this afternoon. The common saying is that when you offer certain men 'medicine to use against ailment, they will ask whether you have experienced the kind of situation; if yes, the next question is, did you use the medicine, and what was your experience? The saying "for better or worse" was derived from the older Sarum Manual and became famous through its presence in the marriage service of the Book of Common Prayer (1549), where the bride and bridegroom each must pledge to hold and stand by the order "for better or worse, for richer, for poorer, in sickness or health." The phrase "for better or worse" means that you accept the positive or negative outcomes of any situation and that these outcomes cannot be changed ("no retreat, no surrender").

The relationship between our world and fungi is a strong and serious bond that could be traced to God's creation of the universe.

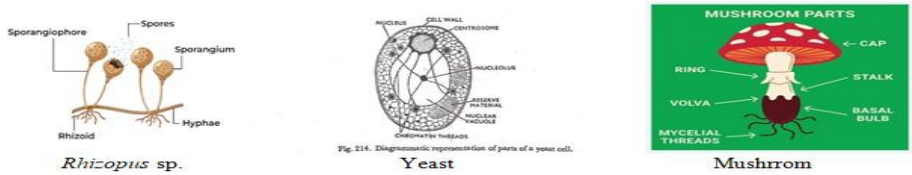
> *1: In the beginning, God created the heaven and the earth*
> *11: And God said, Let the earth bring forth grass, the herb yielding seed, and the fruit tree yielding fruit after his kind, whose seed is in itself, upon the earth: and it was so.*
> *24: And God said, Let the earth bring forth the living creature after his kind, cattle, creeping thing, and beast of the earth after his kind, and it was so .* (Genesis 1:1, 11, 24)

In the biblical creation worldview, God created fungi during the creation week as a variety of reproductively isolated kinds or baramin (*bara* = created, *min* = kind; Marsh 1941). The Bible does not describe precisely when fungi were created, but we can logically deduce when they were likely created based on the reasoning that each created system at the end of each day was complete or "good" (*Genesis 1*; Gillen 2008). In this way, we can deduce that fungi, along with plants, were likely created on Day 3, given the traditional Hebrew inclusion of fungi in the plant kingdom (Gillen 2008; Kennard 2008).

1.0 INTRODUCTION

1.1 What are fungi?

Mr. Chairman,Sir, ladies and gentlemen, join me on a journey into the mysterious world of Fungi to witness their beauty, unravel their mysteries and discover how this secret kingdom is essential to life on earth and such hold the key to our future. Fungi are among the most important inhabitants of the natural world, and everyone must have a fundamental knowledge of what fungi are(Figures 1 and 2), what they look like, where they occur, and what they do. Fungi are cosmopolitan and abundant in nature but often overlooked, usually underappreciated, and sometimes misunderstood. Their sudden appearance and disappearance, frequent association with decaying organic matter, their vivid colours, fantastic shapes, and, in some instances, their poisonous properties often cause fungi to be regarded as objects of mystery and sometimes even to be associated with the supernatural.



Rhizopus sp. Yeast Mushrrom

Figure 1: Structures of various fungi (Source: Geeksforgeeks.org)

Puff ball mushroom Buton mushroom *Gernoderma* sp. Cup mushrrom

Figure 2: Various types of mushroom (Sourse:https://www.gettyimages.ca/detail/photo/cup-fungus;https://foragerchef.com/)

Fungi are classified as shown in Figure 3 below.

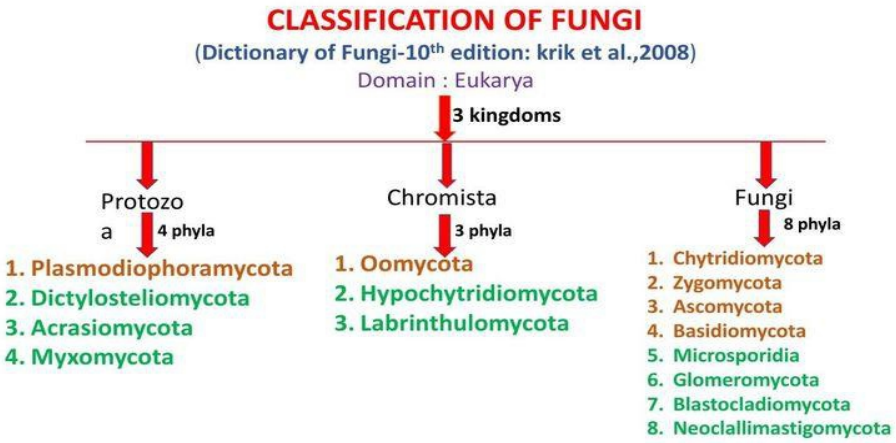


Figure 3: Classification of fungi(Krik *et al*., 2008)

To make my lecture more explicit and my contributions appreciable, l will briefly open your mind to the good and the bad facets of the fungi and "mankind" that made the relationship for better or worse and no retreat, no surrender**.**

2.0 BENEFICIAL ROLES OF FUNGI (HOW FUNGI SHAPE OUR EARTH)

Fungi are a fascinating and charismatic kingdom woven into every part of our environment. Mankind depends on them day in and day out for its very existence. It was fungi that inherited the world after the last mass extinction event and brought life back to earth. From the earliest moments of life on land, fungi have been nature's great survivors, influencing evolution in remarkable ways. However, fungi are relatively understudied despite forming an essential, fascinating and biotechnologically valuable group of organisms with an incredible potential for idustrial exploitation.

2.1 Fungi in Agriculture:

Fungal activity in farmlands contributes to the growth of plants by about 70%. And it was because of fungi that plants could move onto land. Fungi acted as the roots of water plants until they could evolve roots, which took some million years.

2.1.1 Fungi as biocontrol agents

Some beneficial fungi, such as those belonging to the genus *Trichoderma, Fusarium* sp., *Colletotrichum* sp., *Phomopsis* sp., *Cercospora* sp., *Beauvarea* sp. *and Metarhizium* sp. are effective biocontrol agents used to control plant diseases, insect pests, weeds and nematodes. Fungi produce secondary metabolites that can act as toxins with fungicidal or insecticidal effects. Examples include Beauvericin, Destruxin, etc (Figure 4 A and B).

Figure 4: A. Beetle killed by *Metarhiziumanisopliae* B. Commercial Organic Insect Controllerfrom *Metarhiziumanisopliae* C Commercial fungus for the control of nematodes D. Nematode killed by fungus

(Sources: https://blueberriesconsulting.com/en/nosotros)

Many post-harvest fungal antagonistic agents are used to preserve post-harvest food crops. Fungi are also used as biofertiliser to increase the uptake of nutrients from the soil and roduce bioactive compounds,

enzymes and hormones that stimulate plant growth. Many beneficial interactions exist between plants and fungi and can be characterised as mycorrhizal, endophytic, or lichen (Deacon, 2006). Fungi connect plants and trees through the "worldwide wood". The mycelia net works in the ground, allowing plants to communicate with each other. When an aphid begins eating the leaves of a plant, it can send out an alarm to others of its kind through the mycelia network, prompting them to put off chemicals that will keep the aphids away. Fungi are crucial for breaking down the stable biopolymer cellulose and for waste management in an eco-friendly and low-cost manner. They propel nitrogen fixation and phosphorus mobilisation. Marine-derived fungi have been used to remove heavy metals in the mycoremediation of textile-based dye.

2.2.0 Fungi in industry

Many fungi have been used to produce drugs like penicillin, organic acids (citric, fumaric, gluconic and lactic acids), and enzymes (amylases, cellulases, keratinases and lipases). Fungi are also used as biomaterials, such as fungus-based textiles, packaging and construction, leather, automotive, thermal insulation, or fire protection material.

2.3.0 Fungi as food

Fungi have been used as food by humans for a long time. Many different kinds of fungi woridwide, *Agaricus* spp. and *Pleurotus* spp., are consumed as edible mushrooms due to their high protein content and a good amount of lysine, an amino acid, minerals, vitamins and fat. Fungal species are essential for cheese manufacture and ripening (Fox *et al.,* 2017). Fermented products using fungi include Soy sau and miso, Quorn, tempeh and rennet (Kozubal *et al.,*2019). Synthetic colourants from fungi are widely used in food production to enhance the appearance of food colours. Microbial fermentation using *Tyromyces chioneus and Saccharomyces cerevisiae* produces flavours and aromas

such as aldehydes, esters, methyl ketones and terpenoids for the production of grape wine (Gupta *et al.*, 2015).

2.4.0 Fungi in Arts, music and architecture

Fungi have appeared from time to time in literature, both for children and for adults. Lewis David von Schweinitz (1780–1834) illustrated over 1000 fungal species, which, along with his contribution to mycology, earned him the title of "Father of North American Mycology". Mushrooms influence music as a subject, cultural reference, or medium for music creation. The Czech composer and mycologist Václav Hálek (1937-2014) is stated to have composed over 1,500 symphonies inspired by fungi, including the composition called Mycosymphony. In architecture and sculpture, mushrooms are mainly represented or showcased in architectural and sculptural designs.

2.4.0 Forensic mycology

Forensic mycology is the use of fungi in criminal investigations. Fungi are used to estimate times of death or events by using known growth rates of fungi, provide trace evidence, and locate corpses. Applications include roles in providing trace evidence estimating time since death (post-mortem interval), ascertaining the time of deposition, investigating the cause of death, hallucinations, or poisonings, locating buried corpses, and biological warfare.

3.0 ADVERSE EFFECT OF FUNGI TO "MANKIND"

This is the other side of the relationship that almost changes the mind of mankind. As a result of man's rebellion, God allowed man to see what the world was like without His sustaining power and maintained all the interconnected relationships He had created. This allowed these relationships to degenerate to varying degrees, typified by the rise of pathogenic relationships between various microbes and vascular plants, animals, and humans. It is interesting that of the estimated 1.5 million

fungi, only slightly more than 10,000 (<1%) are known to create harm by spoiling food, destroying timber, and causing diseases of crops, livestock, and humans(Agrios, 2005).

In man, fungi cause over a million eye infections yearly, resulting in blindness. Fungi are increasingly linked to myriad human ailments, such as allergic and asthmatic diseases that affect millions of people. Most women suffer from at least one fungal infection, such as infection of the hair, skin or nails, thrush, and a significant proportion experience these regularly. In animals, fungi like *Saprolegnia parasitica*, an aquatic fungi, live as parasites on eggs and gills of fishes. *Aspergillus* causes aspergillosis in dogs and poultry; *Trichophyton* causes dermatophytosis in cattle. Damage to clothes: fungi can grow on wet clothes and shoes, thus causing damage to them. Clothes from natural fibres such as cotton, linen, rayon, wool and silk are more susceptible to fungal damage than synthetic fibres. Mould on clothes produces enzymes that breakdown the cellulose or protein into compounds that the mould uses as food, e.g.*Aspergillus niger*. Damage of paper, wood and building materials: Filamentous fungi belonging to the Ascomycota phylum including genera *Aspergillus, Penicillium, Chaetomium, Stachybotrys;* Basdiomycota e.*g. Pluerotus and Gernoderma* are the main fungi deteriorating paper-based, wood, and building materials, being mainly responsible for the appearance of different colour patches with biological origin on paper, wood and building materials. Mycotoxin production causes loss in farm animals and renders a commodity unacceptable in nationally or internationally.

Figure 15: Fungi diseases of man A. *Tinea capitis* B. *Tinea pedis*
Source: www.researchgate.net

Mr Chairman, Sir, ladies and gentlemen, at this juncture, I will like to restrict the remaining part of this lecture to my area of specialization, which is plant biology.

Fungi that cause disease in plants are the same or very similar to those causing disease in humans and animals. Man has painfully recognised the occurrence of plant diseases in the early times of antiquity. This is evidenced by mentioning rust, smut, downy mildew, powdery mildew and blight crops as great scourges of humankind in the Old Testament that date to the fifth and eighth centuries B.C. The potato blight in Ireland and northern Europe, rampant during two successive seasons (1845–1846 and 1846–1847), was caused by the fungal-like organism *Phytophthora infestans*. This single organism caused the death of more than 1 million people by starvation and initiated one of the largest human migrations on the planet. Mycotoxin contamination of food occurs due to crop invasion by field fungi, e.g., *Fusarium* spp. *and Alternaria* spp. Significant crops vary widely in susceptibility to mycotoxin contamination. Corn (maize) is widely considered among the most susceptible major crops to mycotoxins, while rice is among the least vulnerable crops. Mycotoxins are very persistent in food, and once they are present, no general mechanisms altogether remove them from any food. Fungi affect plants and inflict disease on them by killing the host or by interfering with its metabolic processes through their enzymes and toxins, weakening the host due to continuous loss of nutrients, interfering with the translocation of food, minerals, land water, suppressing the chlorophyll content, reducing the leaf area, curbing the movement of solutes and water through the stems, sometimes reducing the water-absorbing capacity of the roots, suppressing the translocation of photosynthates away from the leaves and sometimes promoting wasteful use of the products of photosynthesis.

Table 1: Specific symptoms of plant diseases caused by fungi

Symptom	Description	Examples
Water-soaking	A water-soaked, translucent condition of tissues caused by water moving from host cells into intercellular spaces	Late blight lesions on potato and tomato leaves
Wilting	Temporary or permanent drooping of leaves, shoots, or entire plants from lack of water.	*Fusarium* wilt of tomato, coffee
Blight/blast	Sudden or total discolouration and killing of large numbers of blossoms, leaves, shoots, or the entire plant;	Fire blight of pome fruit. Rice blast, Corn Leaf Blight
Canker/anthrcnose	A definite, dead, often sunken, swollen and cracked area on a stem, trunk, tuber, or root surrounded by living tissues.	Anthracnose of beans, tomato, cucurbit, onion stem canker of soybeans,
Damping-off	Decay of seed in the soil, rapid death of germinating seedlings before emergence, or emerged seedlings suddenly wilting, toppling over, and dying from rot at or near the soil line	Pre-emergence damping-off of water melon by *Pythium*

Rot(soft/dry/black)	Decomposition and putrefaction of cells, later of tissues and organs	*Pythium* Seed Rot, Soft Rot of potato, *PhytophthoraRhizopus* Soft Rot of Fruits and Vegetables, Black pod of cocoa
Spot(leaf/fruit/brown	A definite, localised, round-to- regular lesion, often with a border of a different colour	Grey leaf spot of tomato; black spot of rose; Banana Leaf Spot
Powdery/downy mildew	Powdery growth/downy patches on the surface of leaves, buds, shoots, fruits and flower	Powdery mildew of cucumber, Downy mildew of maise

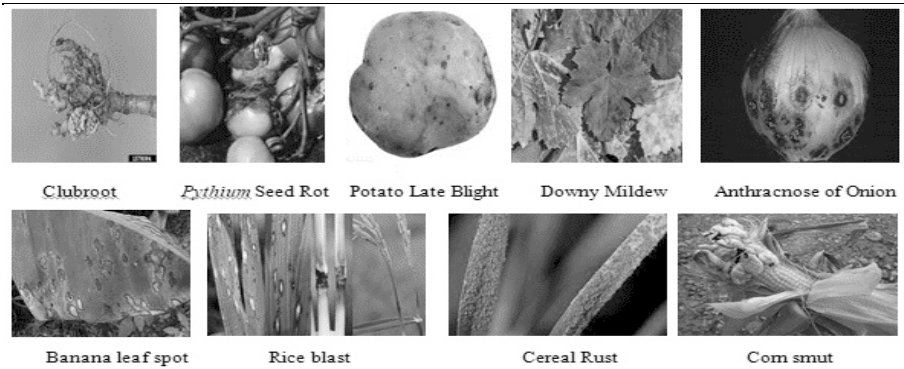


Figure 6: Fungi disease symptoms in plants (**Source**: https://www.ctahr.hawaii.edu/UHMG/conference)

4.0 EFFORTS OF "MANKIND" TOWARDS COPING WITH FUNGI

4.1 Detection of fungi responsible for the diseases in plants

The puzzle of what caused the blight of potatoes in Ireland continued unanswered for 16 years after the 1845 destruction of potatoes by the blight. Finally, in 1861, Anton deBary did a simple experiment that proved that a fungus caused the potato bight. deBary planted two sets

of healthy potatoes, one of which he dusted with fungus spores collected from blighted potato plants. When the tubers germinated and began to produce potato plants, the healthy tubers produced healthy plants. In contrast, the healthy tubers dusted with the fungus spores became blighted and died. Therefore, the unknown fungus was now known as *Phytophthora infestans,* an Oomycetes. The availability of improved magnifying lenses and microscopes, the advent of techniques, remote sensing, digital image analysis, and the development and introduction of techniques for growing microorganisms (fungi) in pure culture by Brefeld, Koch, Petri, and others (1875–1912), etc have made the detection of fungal pathogens within plant tissues possible in the early stages of infection and contributed significantly to plant pathology.

4.2 Management of fungi diseases in plants

4.2.1 Plants defend themselves (Mechanism of self-protection by plants)

Plants respond against fungi attacks through various morphological, biochemical and molecular mechanisms. The defenses may be pre-exiting (mechanical, such as thick epidermal cells, wax cuticle or natural opening, preventing spore adherence or penetration, or biochemical, e.g. saponins that disrupt fungal membranes). Other defences are induced when a fungus pathogen attacks, e.g. cells may form lignin, gums, tylose, cork, abscission layer, or callose barrier may form. In many species, antimicrobial phytoalexins are produced(Wang *et al*., 2004).

4.2.2 Historical methods of controlling fungi

The efforts of early scientists such as De Bary, Speerschneider, and Kühn to find the causes of plant diseases established plant pathology as a critical discipline in the struggle to prevent catastrophic crop failure.

In many early references, plant diseases were considered a curse and a punishment of the people by God for wrongs and sins they had committed. This implied that plant diseases could be avoided if people

abstain from sin. In the fourth century b.c, the Romans suffered so much from hunger caused by the repeated destruction of cereal crops by rusts(fungus infestation) that they created a separate god named Robigus. To please Robigus, the Romans offered prayers and sacrifices, believing that he would protect them from the dreaded rusts. The Romans even established a memorable holiday on the 25th of April for Robigus, the Robigalia, during which they sacrificed red dogs, foxes, and cows in an attempt to please and pacify Robigus so he would not send the rusts to destroy their crops(Doehlemann *et al.*, 2017).

4.2.3 Modern methods of fungi control

Today, the endless variety and complexity of many diseases of plants caused by fungi and pseudo-fungi have led to the development of a correspondingly large number of approaches for their control. The particular characteristics of the life cycle of each fungus, its habitat preferences, and its performance under certain environmental conditions are some of the most essential points to be considered in attempting to control a plant disease caused by a fungus. Some control available are chemical, biological, cultural eradication, exclusion, etc. However, although some diseases caused by fungi can be controlled completely by just one method of control measure, an integrated approach to disease management and control is essential for most fungal diseases of plants. Also**,** several disease-forecasting models were created to help develop decision support systems for timing chemical applications to control fungi. Examples include Potato late blight (*Phytophthora infestans*) forecasting models, tomato early blight forecasting models of *Alternaria solani* on tomato

5.0 MY CONTRIBUTIONS

5.1 My area of specialisation

I am a Plant Pathologist and specialised in Mycology, where I earned my PhD degree in 2009 from the University of Ilorin, Nigeria.

Mr Chairman, Sir, the research conducted by my research and I covered aspects of pathogen biology, disease diagnosis, plant resistance and disease control on various crops (vegetables, fruits, ornamentals, and industrial crops). These will be presented in the following steps:

i). Isolation and identification of fungi, ii). Biological control of plant diseases caused by fungi pathogen, iii). Plant Resistance to disease, iv). Mushr oom culture

5.2.Isolation and identification of fungi

Mr Chairman Sir, I would like to state my contribution to the field of phytopathology, starting with the isolation and identification of fungi. During my research, we(the research team/group) isolated approximately 200 fungal isolates comprising 120 species in 22 genera from different sources such as soil, water, food materials and plant parts (fruits and leaves)(Table 2). The isolation was done by inoculating (1ml) from serially diluted materials or infected parts on Potato Dextrose Agar (PDA) in the Petri dish. The plates were incubated at 28±2^{o}C for a week, then the fungal colonies were observed, and pure cultures were maintained at 4^{o}C. The identification of fungi at the genus level was done using macroscopic and microscopic examinations depending on the colony colour, shape, hyphae, conidia, conidiophores and arrangement of spores. Molecular identification of the isolated fungi at the species level was done to clarify the relationship between species, which are poorly distinguished by their morphology. The study on isolation and identification was very important because understanding the identity and genetic complexity of a pathogen infecting a particular host is essential for effective disease management strategies.

Table 2: Fungi isolated and identified from various sources

Source	No of Isolated Fungi species	Genera of the species isolated	References
Stored garri	6	*Aspergillus;Penicillium*	Amadi and Adebola (2008) Adebola *et al*. (2014)
Water mellon	1	*Botrytis*	Adebola *et al*.(2019)
Cocoa	15	*Aspergillus;Penicillium; Trichoderma,Rhizopus; Phytophthora; Paecilomyces; Botryodiplopoda*	Adebola and Amadi (2010, 2011, 2012, 2014)
Leaves, stems and pods	5	*Aspergillus; Fusarium; Rhizopus, Mucor*	Muhammed *et al.* (2013, 2017)
Tomato		*Tricophton*	Olayinka *et al.* (2013)
Ground nut	19	*Aspergillus; Penicillium; Trichoderma; Rhizopus; Phytophthora; Fusaeium; Armillaria; Cercospora*	Amadi *et al*. (2014)
Stored Mellon	4	*Aspergillus; Penicillium; Rhizopus; Fusaeium*	Adeleke *et al.* (2013)
Snacks	7	*Aspergillus; Penicillium; Rhizopus; Fusaeium*	Amadi*et al.* (2014)
Banana	1	*Fusarium*	Abdullahi&Adebola (2018)

Fish/water	16	*Aspergillus; Penicillium; Rhizopus; Mucor Fusarium4*	Adamu *et al.(* 2018) ; Ibrahim *et al*. (2015)
Cow dung	15	*Aspergillus; Penicillium; Trichoderma; Rhizopus; Rhodotorula; Fusaeium; Mucor; Cunninghamella*	Ozaze&Adebola (2019)
Insect	2	*Isaria; Metharhizium; Beauveria;Entomophaga*	Kalesanwo *et al.*(2019)
Soil	15	*Aspergillus; Penicillium; Trichoderma; Rhizopus; Rhodotorula; Fusaeium; Mucor; Cunninghamella*	Ozaze&Adebola (2019)
Castor plant	1	Cercospora	Salihu *et al*. (2019)
Irish Potato	1	*Rhizoctonia*	Adebola *et al.*(2020)
Pearl millet	1	*Pyricularia*	Abubakar *et al*. (2020)
Jute	4	*Aspergillus; Mucor*	Muhammed *et al*. (2014)
Amaranthus	4	*Aspergillus; Mucor*	Muhammed *et al*. (2015)

5.3. BIOLOGICAL CONTROL OF FUNGI PATHOGENS(Fungi as antagonists)

Biological control, in its most basic form, is the employment of living organisms to combat a specific plant disease or pest through parasitism, antibiosis, or competition for resources or space. Organisms from the rhizosphere can be harnessed from the surrounding environment (the **black box approach**) or introduced into the field from external sources (the **silver bullet approach**).

5.3.1 Black pod disease of Cocoa(*Theobroma cacao*)

My contribution to plant disease control utilised black box and silver bullet approaches. My long-day dream as a boy who grew up in a cocoa farm was to know the pathogen of cocoa black pod disease that causes substantial annual crop losses in cocoa farms and how it could be controlled. Just like Archimedes, who shouted," Eureka "I found it". In 2009 during my PhD research programme, I isolated and identified two species of fungi that caused black pod disease viz: *Phytophthora palmivora* and *P.megakaya* using different culture nutrients (PDA and Cocoa Dextrose Agar "CDA")(Adebola and Amadi,2012). To control these pathogens, I tested fifteen (15) potential antagonistic fungi isolated from soil, cocoa pod and leaves from the cocoa farm(*Aspergillus fumigatus, A. repens, A. flavus, A. niger, Paecilomyces* sp*., Trichoderma harzianum, Botrydiploidia theibromae, Penicillium digitatum Rhizopus stolonifer* and *Alternaria tenuis*)using dual culture techniques against *P. palmivora* out of which ten effectively control the growth of the pathogen (Adebola and Amadi, 2010; 2011a &b; 2012a, b, c and d). The percentage inhibition of pathogen growth observed in each medium was well above 60%. The temperature range for the antagonistic activities was between 15- 35°C outside, which the antagonistic activities dropped. The effect of pH range on antagonism was significantly ($P<0.05$) decreased with an increase in pH. Strong antagonism of the pathogen was observed between pH 5 - 6.5. The results from nutritional factors on antagonistic activities revealed that the antagonistic effects were not significantly different ($P>0.05$) among the supplements used but were highest in pectin- and glucose-supplemented media, suggesting that nitrogen and carbon sources were essential for the successful production of inoculum biomass as well as for sustaining biological activities. The efficacy of these tested fungi under field conditions was investigated (Tables 3 and 4) to compare the potential antagonists with the conventional fungicides(Metalaxyl-m and cuprous oxide). The percentage pod infection by the pathogen was deficient and not significantly different ($p>0.05$) in plots treated with chemicals and *Trichoderma harzianum* (Adebola *et al.,* 2014). These

results raised the hope that if the biocontrol agent is effectively applied, the establishment of the pathogen on the pod would be prevented, thus encouraging flower production and invariably improving the yield.

Table 3: Radial growth (mm), percentage inhibition and pathogen inhibition zone in dual culture with potential antagonists

Potential antagonist	*Mean radial growth (mm)	*Mean % inhibition	*Mean zone of Inhibition
Alternaria tenuis	27c	35a	13a
Trichoderma harzianum	10a	76d	16a
Botryodiploidia theobromae	17b	56b	11a
Penicilliu. Digitatum	10a	74cd	13a
Phythophthora palmivora	39d		

* Mean of three replicates at 9 days of incubation Means in a column followed by different letters differ significantly at P = 0.05 (DMRT)

Table 4: Effects of treatments on cocoa pod production six weeks after spraying

Treatment	*TNP	*NHP	*NIP	* % infection
Water	18a	14a	4a	22e
Rhizopus. Stolonifer	27c	24b	3a	11b
Trichodermaharzianum	28c	26c	2a	7a
Fungicide	28c	27c	1a	3a

*Mean per plot in a column followed by different letters diffesr significantly at P = 0.05 (DMRT). TNP=Total no of pods; NHP= No of Healthy Pod; NIP= No of Infected Po

5.4 PLANT EXTRACTS FOR THE CONTROL OF FUNGI PATHOGENS

We screened and evaluated about 56 indigenous plant extracts on the control of various plant/crop disease pathogens(Table 5). The screened plant extracts were made from different plant parts (leaves, stems, roots, flowers and seeds) by either filtration, Soxhlet or serial exhaustive methods using either of the solvent, hexane, dichloromethane, chloroform, acetone, butanol and/or their correct combination(Adebola *et al.*, 2018 and 2020). The extracts were found to contain either of the following phytochemicals: phenolics, flavonoids, proteins, amino acids, steroids, alkaloids, and saponins, with antifungal activities (Adebola *et al.*, 2016 a and b; 2018; 2019 and 2020)

Table 5: Screening indigenous plant extract against fungi disease pathogen

Name of disease	Name of pathogen	Sources of plant extract	Part of plant used	References
Red rot of Sugar cane	*Colletotricum falcatum*	*Argomone mexican; Hyptis sauveolens; Corchurus olitorius* and *Cymbopogon citratus*	Leaves	Adebola *et al*. (2016)
		Azadirachta indica; Lawsonia	Leaves	Egubagi *et al*. (2019)

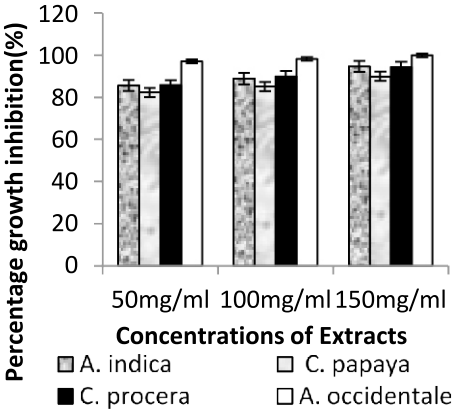
		inermis; Khaya senegalensis		
Leaf spot of ground nut	*Mycosphaerella arachidis*	*Entada africana; Vitex doniana; L. inermis; A. indica*		Adebola &Amad (2016)
Leaf wilt and stem rot of Sesame	*Rhizoctonia solani*	*A. indica; Alium cepa; Amurraya koenigli*	Leaves	Ajayi *et al*. (2017)
R ice blast	*Magnaporthe oryzae*	*Carica papaya; A. indica; Calotropis procera; Anacardium occidentale*	Leaves/Stem bark	Adebola *et al*. (2018)
Panama disease of banana	*Fusarium oxysporum*	*Acacia nilotica; L. inermis; Ziziphus spina-christi*	Leaves/bark	Abdullahi *et al.* (2018)
Damping off of Watermelon	*Botrytis cinerea*	*C. procera; A. indica;A. occidentale*	Leaves	Adebola *et al.* (2019)
Black scurf in Iris potato	*Rhizoctonia solani*	*Aclypha wilkesiana; Moringa oleifera; C. papaya*	Leaves	Adebola *et al*. (2020)
Fruit rot in sweet orange	*Fusarium oxysporum*	*Zingiber officinale; Vernonia*	Rhizomes/ leaves	Adebola *et al*.(2020)

		amaygdalina ; Hyptis sauveolens		
Anthracnose of banana	*Collectotrichum musae*	*C. procera; A. indica; A. occidentale*	Leaves / stem bark	Adebola *et al.* (2020)

5.4.1 Antifungal growth inhibition of rice blast, Irish potato black scurf and banana anthracnose disease pathogens using plant extracts.

We (Adebola *et al.,* 2018) investigated the *in vitro* effects of leaf extracts on: (i). rice (*Oryza sativa*) blast pathogen *(Magnaporthe oryzae)* with four medicinal plant extracts (*Carica papaya, Azadirachta indica, Calotropis procera and Anacardium occidentale*), (ii). *Rhizoctonia solani,* the pathogen of Irish potato black scurf disease(Adebola *et al.,* 2020 a) using three botanical extracts from *Acalypha wilkesiana*, *Moringa oleifera* and *Carica papaya* leaves, and (iii). *Colletotrichum musae*, is the pathogen of anthracnose disease of banana fruits (Adebola *et al.,*2020b).

In each case, the phytochemical constituents of the extracts were ascertained using standard procedures, and the toxicity of the extracts was tested against the pathogens at different concentrations using the agar well diffusion method. We observed that the extracts showed various antifungal activities against the pathogens. (Figures 7,8 and 9). The potency of all the plant extracts increased with the increase in concentration. *A. occidentale* extracts gave the highest percentage of growth inhibition of *Magnaporthe oryzae, M. oleifera* extract gave the highest percentage of growth inhibition of *R. solani,* while *C. procera* gave the highest percentage growth inhibition of *Colletotrichum musae*(Table 6). Therefore, the extracts raised the hope of controlling theses diseases if the field trial is conducted. They could be cheaper substitutes for conventional fungicides in preventing diseases since they are easy to prepare via a simple process of maceration or infusion.


120
100
80
60
40
20
0
Percentage growth inhibition(%)
50mg/ml
100mg/ml
150mg/ml
Concentrations of Extracts
A. indica
C. papaya
C. procera
A. occidentale

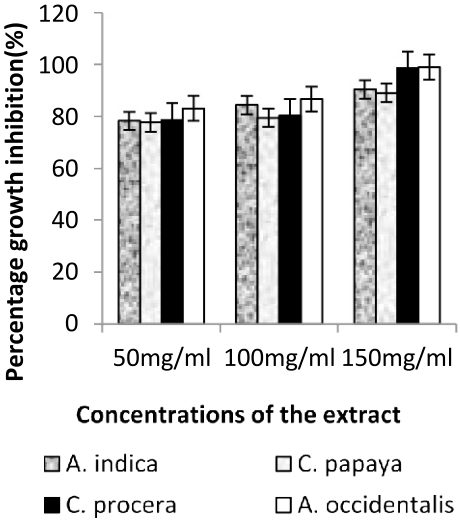

120
100
80
60
40
20
0
Percentage growth inhibition(%)
50mg/ml
100mg/ml
150mg/ml
Concentrations of the extract
A. indica
C. papaya
C. procera
A. occidentalis

Table 6: Percentage Growth Inhibition of *Rhizoctonia solani* by the three plant leaf extracts

Sample	*C. papaya*	*A. wilkesiana*	*M. oleifera*
25%	16.67±1.36[b]	10.53±0.71[b]	25.17±0.84[b]
50%	33.13±1.24[c]	21.77±1.08[c]	48.97±0.84[c]
75%	60.73±2.11[d]	35.57±0.83[d]	79.00±1.44[d]
Control	0.00±0.00[a]	0.00±0.00[a]	0.00±0.00[a]

Values followed by the same superscript alphabets on the same column are not significantly different at p>0.05. Values are presented in mean ± standard error of three replicates

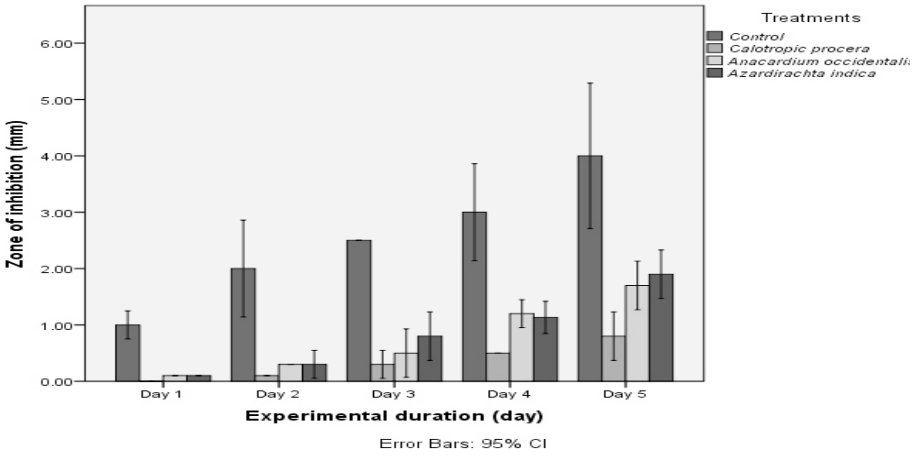


Figure 9: Inhibition of *Collectotrichum musae* by Plant extracts

5.5. 0 CONTROL OF POST-HARVEST DISEASE PATHOGENS

Post-harvest losses refer to the losses that occur along the food supply chain due to pathogens infection, handling, storage, transportation and processing, thereby reducing the quality, quantity and market value of agricultural commodities. The principal genera of mycopathogenic fungi that cause crop deterioration and food poisoning are *Alternaria, Aspergillus, Botrytis, Fusarium,* and *Penicillium.* The following were my contributions:

5.5.1 Effect of moisture content on Storability of Garri

Amadi and Adebola (2008) assessed the effects of moisture content and storage conditions on the storability of garri. Yellow and white garri samples obtained from different markets in Ilorin were stored under the same conditions using polythene, jute and plastic containers for 3 months. The moisture contents of the yellow and white samples were 17.8 and 17.2%, respectively, against a 12.7% safe level. Results showed that moisture content in storage increased with time in the two samples. Mouldiness was also observed in the stored garri samples. Five mould species isolated were *Aspergillus niger, A, fumigatus, A. flavus, A. glaucus, Penicillium* sp. and *Rhizopus* sp. Air-tight polyethene and plastic containers preserved garri better than jute bags. Nutrient components and physical properties of garri also depreciated in samples stored in jute bags. Biochemical analysis revealed that starch, sugar, proteins and lipids were significantly reduced with time and increasing moisture content. Market survey in this study showed that garri samples sold in Ilorin generally have high moisture contents. Similar research was also carried out by Adebola *et al.*(2014) on the effects of packaging materials on the shelf-life stability of garri bought from markets in Lapai, Niger State, Nigeria. Samples of white garri were collected at weekly intervals in May, June and July 2011 from Central and Gbako markets in Lapai Local Government Area, Paikoro and Tunga-mallam markets in Paikoro Local Government Area, all in Niger State, Nigeria. The purchased garri, with an initial moisture content of 14.30 %, was aseptically weighed (5 kg/pack) into Polythene bags, Fertiliser bags and

Plastic buckets. These were stored at 28 ± 2°C for eight months. The changes in the sample moisture content, associated fungi, biochemical and sensory quality were monitored. The result revealed that the average moisture content of garri offered for sale in these markets (13.90 %) was slightly higher than the safe level (12.70 %). The moisture and mould contents increased with the storage period, while the nutritional content and PH were reduced. The degree of deterioration was generally low and was in the order of Plastic buckets < Polythene bags< and Fertiliser bags(Table 7). Changes in the various sensory quality attributes, such as colour, aroma, texture, and mouldness at the end of the storage period, followed the same trends. Four fungi species (*Aspergillus niger, Aspergillus flavus, Aspergillus fumigatus* and *Rhizopus stolonifer*) (Table 8) were isolated during the storage period in all the packaging materials. The total viable fungal count was in the order fertiliser bags > Polythene bags > plastic buckets. Overall, air-tight plastic buckets or polythene bags were recommended as the best packing materials for garri for an extended period at a safe moisture content level.

Table 7: Changes in the physicochemical and nutritional quality of garri in different packaging

materials at the end of the storage period of 8 months.

Parameter	Initial or before storage	Polythene bags	Fertiliser bags	Plastic buckets
M C (%)	14.30 ± 0.01	14.48 ± 0.25	15.41 ± 0.03	14.43 ± 0.05
PH	4.12 ± 0.01	4.00 ± 0.08	4.00 ± 0.10	3.81 ± 0.01
CHO (%)	73.31 ± 0.34	69.15 ± 0.07	68.54 ± 0.32	68.62 ± 0.32
protein (%)	2.34 ± 0.01	1.65 ± 0.11	1.01 ± 0.03	1.99 ± 0.02
lipid (%)	0.63 ± 0.02	0.58 ± 0.04	0.53 ± 0.01	0.60 ± 0.01

HCN (mg/g)	3.71 ± 0.01	2.20 ± 0.14	2.11 ± 0.4	2.34 ± 0.00

Each value is the overall mean ± standard deviation for duplicate determinations

Table 8: Fungi Isolated from stored Garri

Mould species	Initial mould	Polythene bags	Plastic containers	Fertilizer bags
		Content		
Aspergillusflavus	0.04 x 10^2	2.00 x 10^2	1.80 x 10^2	2.10 x 10^2
Aspergillusniger	0.01 x 10^2	1.50 x 10^2	1.40 x 10^2	1.60 x 10^2
Aspergillusfumigatus	0.01 x 10^2	1.00 x 10^2	0.90 x 10^2	1.80 x 10^2
Rhizopusstolonifer	0.02 x 10^2	1.30 x 10^2	1.20 x 10^2	1.70 x 10^2
Total mould	**0.08 x 10^2**	**5.80 x 10^2**	**5.30 x 10^2**	**7.20 x 10^2**

5.5.2 Mycoflora associated with herbal concoction

The occurrence of mycoflora contamination in some herbal concoctions sold in Lapai, Niger State, Nigeria, was evaluated by Adebola and Yakub (2016). A total of 12 samples of herbal concoctions were collected from herbal vendors from central markets in Lapai, Niger State, Nigeria. Each concoction was serially diluted, and fungi contaminants were isolated on potato dextrose agar using 1ml of each solution from 10^{-3} and 10^{-4} dilutions. Some physicochemical parameters were also determined using standard methods. Six different fungal species, including; *Microsporum audouinii*, *Mucor* species, *Aspergillus fumigatus, Aspergillus flavus, Aspergillus niger* and *Penicillium notatum,* were isolated and identified(Table 9). *Penicillium notatum* had

the highest frequency of occurrence (29.26%), followed by *Aspergillus niger* (26.82%), *Aspergillus fumigatus* (21.95%), *Aspergillus flavus* (9.75%), *Microsporum audouinii* (7.31%) while *Mucor hiemalis* had the least occurrence of (4.87%)(Table 10). The results revealed that the herbal mixtures had no manufacturing or expiring dates. The colour of the samples varied between brown, green, yellow, yellowish brown, reddish brown, yellowish green and cloudy white; the pH ranged between 3.22 and 6.82, the turbidity ranged between 122.5 and 908, while suspended solids (mg/L) ranged between 340 and 4105. All the concoctions had a mean score below with a disease score of 3 on a 1-4 scale for the entire sensory attribute analysed except for miscarriage and tooth pain concoctions, which had taste scores of 3.21 and 3.30, respectively. This study revealed that herbal concoctions sold in Lapai were mainly contaminated with fungi and had poor sensory attributes, inadequate pH, no expiry dates, and no batch number and NAFDAC numbers. Based on this, adequate control measures and distribution practices should be adopted to check the concoction's fungal density, especially *Aspergillus* spp. and *Penicillium* spp., which are of public health importance and improve the safety. NAFDAC/FDA should enforce the regulations required to provide stability testing data with a proposed expiration date and storage conditions. This will provide confidence that the product will meet the applicable standards of strength, quality and purity throughout its shelf life.

Table 9: Fungal isolated from herbal preparation sold in Lapai, Niger State

S/n	Names	Fungal isolates
1	Malaria	*Aspegillusniger, A. fumigatus, Microsporumaudouinii, Mucorhiemalis,* and*Penicilliumnotatum.*
2	Ulcer	*A. niger, A. fumigatus, P. notatum.*
3	Weakness.	*A. niger, A. fumigatus, A. flavus, P. notatum,*

4	Backache	*A. fumigatus, A. niger, P.notatum, M. audouinii.*
5	Diabetes	*A. niger, A. flavus, P. notatum*
6	Fibroid	*A. niger, A. flavus and P. notatum*
7	Menstruation problem	*A. niger, A. flavus*and *P. notatum*
8	tooth pain	*A. niger, A. fumigatus and P. notatum.*
9	Hypertension	*A. niger, A.fumigatus, P. notatum*and *M. audouinii.*
10	Miscarriage	*A.niger, A.fumigatus and P. notatum*
11	Pile	*A, fumigatus. notatum*and *Mucorhiemalis.*
12	Rheumatism	*A. niger, A. fumigatus and P. notatum*

Table 10: Percentage occurrences of Fungal isolates in herbal preparation sold in Lapai, Niger state.

Fungal isolates	samples examined	Positive samples	% occurrence
Aspergillusniger	12	11	26.82
Aspergillusfumigatus	12	9	21.95
Aspergillusflavus	12	4	9.75
Penicilliumnotatum.	12	12	29.26
Mucorhiemalis	12	2	4.87
Microsporumaudouinii	12	3	7.35

5.5.3 Prevalence of Toxigenic Mycoflora in Groundnut Cake (Kuli kuli)

The deterioration of groundnut cake ('kuli kuli'), a by-product of processed groundnut oil consumed widely in Nigeria, is of great concern. Therefore, Musa *et al., 2*021 and 2022 investigated the

toxigenic mycoflora commonly present in kuli kuli sold in the markets in Niger state, Nigeria. Eighteen (18) samples were collected from 10 markets across each of the three agricultural zones of Niger state, namely; Bida, Mokwa (zone 1), Minna, Shiroro (Zone 2), Kotongora, and Kagara (zone 3). The associated fungi were isolation on PDA inoculated with 10^{-4} dilution factors and incubated at room temperature. A total of 166 fungal species were isolated and identified belonging to the genera *Aspergillus, Penicillium, Rhizopus,* and *Fussarium*. The order of percentage occurrence was *A. niger* (27.11%)>*A. flavus* (19.88%)>*P. chrysogenum* (16.87%)>*A. parasiticus* (11.45%)>*Rhizopus* spp.(10.84%)>*A. fumigatus* (9.03%)>*F. oxysporum* (4.82%). The result indicates that the majority of fungi isolated from kuli kuli sold in the markets in Niger state are toxigenic. Therefore, improved management of the raw materials(Ground nuts) from the farm, good post-harvest, storage, and processing will enhance quality and reduce the contamination of kuli kuli.

5.5.4 Fungicidal efficacy of free and nano-encapsulated chitosan against *Aspergillus flavus* isolated from rice (*Oryza sativa*)seeds

Aflatoxins produced by *Aspergillus* species are grains' most harmful and carcinogenic mycotoxins. Synthetic fungicides are widely used for the control of mycotoxigenic fungi in grains. However, rising public awareness about the toxicological effects of fungicides on human health necessitates the development of non-toxic bio-fungicides. In this connection, reports have shown that chitosan synthesised from shell waste has the potential to serve as an alternative fungicide. Therefore, Aremu *et al.(*2023) evaluated the *in vitro* fungicidal efficacy of complementary and nanoencapsulated chitosan against *Aspergillus flavus* isolated from rice (*Oryza sativa*)seeds. High molecular weight chitosan was purchased, and the *in-vitro* antifungal efficacy of chitosan against *A. flavus* was tested using the food poisoning method. Nano-encapsulated chitosan was synthesised using the ionic gelation method, and the particle size was determined. Nano-encapsulated chitosan with

particle sizes of 525.4 nm, 468.3 nm, and 711.7 nm were obtained. 100% *M*ycelial growth inhibition of *A. flavus* was obtained at 1.5% and 2.0% free chitosan. Nano-encapsulated chitosan with particle size (nm) of 525.4, 468.3, and 711.7 at 0.50% gave the best inhibition of 61%, 84% and 87%, respectively. This study showed that free chitosan and nano-encapsulated chitosan are potential antifungal agents for controlling *A. flavus*, the aflatoxin producing fungus.

5.6. BIOREMEDIATION USING FUNGI

5.6.1 Oil-degrader fungi associated with degradation of spent oil contaminated soil

Osazee *et al*.(2019) investigated the oil-degrader fungi associated with the degradation of spent oil-contaminated soil in five selected mechanic workshops in Minna. Samples of the spent engine contaminated soils were collected from Chanchaga, Maikunkele, Shiroro, Tunga and Bosso mechanic workshops located in Minna Local Government Area, Niger State, Nigeria. The fungi were isolated from the soils using the serial dilution plate method. All the fungi were identified based on macroscopic and microscopic features of the fruiting bodies and hyphal spores mass. Fifteen (15) fungal isolates belonging to eight genera were obtained from spent engine oil-contaminated soil in all sampled locations. Fungal species isolated were *Aspergillus niger, Rhizopus stolonifer, Fusarium oxysporium, Aspergillus flavus, Penicillium notatum, Aspergillus fumigatus, Trichoderma harzianum Penicillium griseofulvum, Rhodotorula rubra Cunninghamella echinulata, Trichoderma viride Penicillium chrysogenum Mucor hiemalis Mucor racemosus* and *Mucor plumbeus*. Tunga soil sample had the highest fungal occurrence of isolates, followed by Bosso and Chanchag,a, while soil samples from Maikunkele and Shiroro had the most minor fungi isolates. *Aspergillus niger, Rhizopus stolonifera* and *Aspergillus flavus* were the prominent isolates from all the sampled locations, while *Penicillium chrysogenum, Mucor hiemalis Cunninsghamella echinulata, Mucor plumbeus* and *Rhodotorula* sp. had least number of

occurrence from all locations. The presence of these three predominant fungal species in the spent engine oil contaminated soil samples is a strong indication that these fungi can be used for remediation of crude oil contaminated soil owing to the diverse metabolic activities and the ability to degrade hydrocarbon to less toxic compounds and water.

5.7. FUNGI IN PURIFICATION OF WATER

Developing a cost-effective and broad-based practical approach to wastewater treatment in developing countries is paramount. On this note, we (Bello *et al*.,2021) modified filters with *Penicillium chrysogenum* culture to enhance the removal of copper and iron contaminants in water. This was done using modified sand filter treatments containing 30 spores/ml, 40 spores/ml, 50 spores/ml (Fungal-based Sand Filter; FSF) and sand filter only (SF). These preparations were used to treat deionised water simulated with two levels of heavy metals: 5 and 10 mgL^{-1} of copper and iron. These simulations were prepared to create commonly observed contamination levels in many water sources. Effluent reductions relative to treatments effects were analysed using standard protocol for eight days under aseptic conditions. It was observed that the copper effluents (10 mgL^{-1}) were reduced to 0.106 mgL^{-1} and 0.198 mgL^{-1} on the eighth day in the 30 spores/ml and control treatments and that the effluents of the different copper concentrations were significantly reduced ($p<0.05$) between the 30 spores/ml and the SF treatments. There was also a significant reduction in the number of copper effluents analysed on the second and eighth days. The general affinity range for iron in the four treatments was 30, 40, SF, and 50, in that order 94.26, 91.66, 87.98 and 85.48 as removal efficiency on iron (5 mgL^{-1}) on the eighth day. Therefore, *P. chrysogenum* is a valuable biosorbent that can help improve wastewater quality through bio-sand filter treatment.

5.8. CROP RESISTANCE TO FUNGAL PATHOGENS

5.8.1. Resistance of rice genotypes to natural population of blast pathogens and their agronomic performance

Resistance development is a concern because the products may become less effective or useless for controlling resistant pathogens. Therefore, the team(Aremu *et al*.,2018) evaluated rice genotypes for resistance to the natural population of blast pathogens and their agronomic performance. Fifteen NCRI advance rice breeding lines and two released (BR1-17) varieties (checks) were collected from the breeding unit of the National Cereals Research Institute (NCRI), Badeggi, Nigeria. These genotypes were screened for resistance to blast disease caused by *M. oryzae* in the blast hot spot and water stress environment. From the results on agronomic performance, the genotype designated as BR3 was discovered to be highly resistant with a minor blast incidence(28%). The blast incidence and severity did not affect the agronomic performance of the rice genotypes, as most of the genotypes yield above the average grain yield of 3 tons/hectare. BR3 may, therefore, be utilised by incorporating it into the breeding programme strategy to control the blast disease of *Magnaporthe oryzae.*

5.8.2: Fungicidal resistance of *M. oryzae* strains

My team (Aremu *et al*., 2017) also evaluated the *in vitro* fungicidal resistance among the strains of *M. oryzae* found in rice fields in Niger State to ascertain the effectiveness of Mancozeb and Benomyl fungicide in vogue. The blast, infested leaves, stems and panicles of rice plants were collected in November 2015 from five farmers' fields located in Gbako, Katcha and Lavun Local Government Areas in Niger State, Nigeria. Isolation of the pathogen was carried out on potato dextrose agar (PDA), and the fungicidal sensitivity test of the isolates was conducted on PDA and amended with Mancozeb and Benomyl fungicides. Ten *M. oryzae* strains designated as MOR001 to 0010 were isolated from all the and exposed to fungicides (Mancozeb and Benomyl). Five strains (MOR001, MOR002, MOR004, MOR005 and MOR008) were resistant to the tested fungicides. Isolate MOR008 was

resistant to mancozeb alone, isolate MOR010) was resistant to benomyl alone, while isolates MOR004 and MOR005 were resistant to both fungicides. Molecular evaluation is recommended to actualise this result further.

5.8.4 Antifungal efficacy of chitosan against *Aspergillus fumigatus*

In another research, we evaluated the antifungal efficacy of chitosan against *Aspergillus fumigatus* associated with stored rice (*Oryza sativa*) leading to its poor quality and loss of economic value (Aremu *et al*., 2023}. To achieve our aim, different concentrations of four types of chitosan: Purchased Low, Medium and high molecular weight chitosan and chitosan synthesised from Crab Shell(using deproteinisation, demineralisation, decolouration and deacetylation procedures) were evaluated with water as the control. The degree of deacetylation of the synthesised chitosan was determined using Fourier transform infrared (FTIR) analysis. The *in vitro* antifungal activity of the chitosan was assayed using the food poisoning method against isolated *Aspergillus fumigutus.* The degree of deacetylation of synthesised chitosan was 98.6%. At 2% concentration, the percentage of mycelia radial growth inhibition of the *A. fumigatus* was 100% with HMWC and MMWC, 85% with CSCS, 36.5% with LMWC and no inhibition with the control. Results revealed the effectiveness of chitosan, with its non-toxic and environmentally friendly properties, as an effective antifungal agent in stored rice and could be used to preserve the quality of stored rice. We also conducted a field trial of the four forms of chitosan and water as the control(Aremu *et al*., 2023). Faro 52 rice variety was collected from the National Cereal Research Institute, Badeggi and planted on a hydromorphic field. All the rice plots were sprayed with *M. oryzae* inoculum and later treated with chitosan, and the control plot was sprayed with water two weeks after transplanting. The blast severity, incidence and other agronomic data were monitored. At 2% concentration of each chitosan applied, the severity of the blast disease was 9.3%, 2.3%, 1.0% and 2.0% HMWC and MMWC, LMWC CSCS, respectively, while it was 83% in the control plot at the end of the trial.

The yield in grains was significantly improved in the same trend. It may, therefore, be concluded that chitosan treatment reduces the severity and incidence of blast pathogens and increases grain yield.

5.8.5: Molecular Diversity in Selected Landraces Resistance to Blast Pathogen (*Pyricularia grisea* Cooke ex Sacc.) of Pearl Millet (*Pennisetum glaucum* (L.) R. Br.) Germplasm from Northern Nigeria.

In our efforts towards food security, we realised that germplasm collection and sourcing for resistant genotypes among the available crop landraces through characterisation and quantification of genetic diversity is essential for introgression(transfer of genetic information from one sp to another) in plant breeding programs. Therefore, a study on the molecular diversity of pearl millet (*Pennisetum glaucum*) landraces was carried out by our team(Abubakar *et al*., 2020) to characterise the crop accessions for resistance to blast fungus pathogen(*Pyricularia grisea* cooke ex sacc.) as well as identify elite accession(s) for the crop improvement. Thirty-five (35) pearl millet germplasm was collected from the major cultivated states in Nigeria. It was screened for blast-resistant genotypes on the field using a Randomized Complete Block Design (RCBD). Selected potentially resistant accessions for blast resistance were further confirmed under screen house conditions and evaluated for genetic diversity using random amplified polymorphic DNA-PCR. Out of the 35 accessions screened for blast, 14 were potentially resistant to blast disease (with a disease score of 3.9 on a 1-9 scale).

Further nursery screening of the potentially resistant accessions to blast showed that NS-YEL-02 was the most highly resistant, followed by NG-ZB-01 with a severity disease score of 0.00 and 0.33, respectively. The molecular diversity of selected 14 resistant and 2 susceptible accessions using random amplified polymorphic DNA showed no specific marker for resistant and susceptible accession to the disease. A total of fifty-nine (59) amplified fragment bands with 10 DNA primers

were generated, of which 53 (89.83%) were polymorphic and 6 (10.17%) were monomorphic. Genetic similarity among the accessions varied from 0.18 to 1.44, with an average gene diversity value of 0.74. A clustered dendrogram of the 16 accessions revealed two major cluster groups: two susceptible (KD-CK-01 and NGB501) accessions with a similarity coefficient of 1.14 and 14 resistant accessions. The clustering of the selected landraces based on resistance and susceptibility by RAPD techniques indicates the possibility of indirect selection of blast-resistant genotypes for the crop. The high resistance and cluster of NS-YEL-02 singly in a group by the makers indicate the uniqueness and its prospect for selection as elite parent accessions in blast disease resistance breeding programs.

5.9.0 CULTIVATION OF MUSHROOMS

5.9.1 Evaluated of myco-chemical, proximate composition, minerals and vitamins content of mushrooms

Mr. Chairman Sir, in recent times, mushrooms have assumed greater importance in the diet of rural and urban populations because they are delicacies. However, most mushrooms consumed were hunted from the wild without knowing their mycochemical composition. This practice is often associated with some degree of negativity and fatality. Therefore, Adebola *et al*.(2016) evaluated myco-chemical, proximate composition, minerals and vitamins content present in three selected and identified mushrooms in Lapai, Nigeria, namely; *Macrolepiota procera, Pleurotus roseus and Cantherelle cibarius* collected from the wild in Lapai, Niger State, Nigeria. The samples were sundried, ground into powdered form, and sieved. Mycochemical, proximate composition, minerals and vitamins analyses were carried out. The results revealed the presence of alkaloid, flavonoid and saponin in all three samples. From the results, the proximate composition carbohydrate content was significantly ($P< 0.05$) the highest, with 30.50% in *M. procera*, 28.8% in *P. roseus* and 29.2% in *C. cibarius*. Crude proteins were 9.8%, 11.43% and 10.2% in *M. procera*, *P. roseus*

and *C. cibarius,* respectively. The mineral composition was rich in potassium and sodium but low in cobalt. *Macrolepiota procera* has the highest significant($P<0.05$) percentage moisture content (18.01%), which was significantly different ($P<0.05$) from others. The three mushrooms' vitamin, ash content and crude fibre significantly different ($p<0.05$). The fat content was generally low, with *M. procera* having 11.50%. *Pleurotus roseus* 13.65% and *C. cibarius* 12.10%. *M. procera* has the highest potassium content of (6.80mg/l) while *C. cibarius* has the lowest (5.40 mg/l). These mushrooms hold tremendous potential to contribute to people's protein, vitamin and mineral needs. Therefore, their commercial production and consumption, especially those on low-fat dietary food, should be encouraged and their use as raw materials in the pharmaceutical industry is recommended.

5.9.1: Effects of different sawdust used as a substrate on the cultivation of mushroom

The oyster mushroom (*Pleurotus ostreatus*) is an edible mushroom with excellent flavour, tastes, and protein. However, its domestication is rare. On this note, Adebola *et al*.(2018) researched to determine the effects of different sawdust used as substrates on oyster mushroom cultivation. Sawdust from the following known wood: *Swietenia mahogani* (Mahogany), *Triplochiton sceroxvlon* (Obeche), *Adansonia digitata* (Baobab), and *Gmelima arborea*(Gmelina) was collected from the sawmill at Metunbi, Minna, Niger State, Nigeria supplemented with 7% rice bran and 1% calcium carbonate. The diameter and length of the stipe and pileus and the proximate composition of the cultivated oyster mushroom *(P. ostreatus*) were determined. The highest average stipe diameter (0.53 cm), length (1.56cm) and pileus diameter and length (2.43cm and 2.73cm, respectively) were obtained in *G. arborea.* The result of the proximate composition(Table 11) showed that *P. ostreatus* grown on the *S. mahogani* sawdust has the highest percentage of carbohydrates (0.30%) and protein 3.30%, followed by *G. arborea* (0.27% and3.20% carbohydrates and protein respectively while *A.*

digitata was the least(0.18%). Fat content was highest in *G. arborea* (0.30%) and the less in *A. digitata* (0.23%). Among all the sawdust used, *G. arborea* gave the best *P. ostreatus* yield, followed by *S. mahogany,i A. digitata*, and *T. scleroxylon*. Therefore, *G. arborea* sawdust and *S. mahogani* sawdust supplemented with 7% rice bran and 1% calcium carbonate are recommended for cultivating of *P. ostreatus*.

Table18: Proximate Composition of Mushroom Samples Produced on Different Sawdust Substrates

Substrates with supplement (7% Rice bran)	Carbohydrate (%)	Protein (%)	Fibre (%)	Fat (%)
*Swietenia mahogani*s	0.30^{b}	3.30^{b}	1.50^{c}	0.25^{a}
Triplochiton sceroxvlon	0.22^{a}	2.50^{a}	1.46^{b}	0.28^{b}
Adansonia digitata	0.18^{a}	3.10^{b}	1.42^{a}	0.23^{a}
Gmelima arborea	0.27^{b}	3.20^{b}	1.47^{b}	0.30^{b}

Values followed by the same superscript on the same column are not significantly different at $P<0.05$. values are in mean ± standard error of two determination.

MY VISION

And the LORD answered me, and said, Write the vision, and make it plain upon tables, that he may run that readeth it. For the vision is yet for an appointed time, but at the end, it shall speak, and not lie: though it tarry, wait for it; because it will surely come, it will not tarry. HABAKKUK 2:2-3

Mr. Chairman Sir, Nigeria has 36 states, all with hospitals. Doctors, nurses, and para-medical staff have many primary health care centres, health posts, and sub-health posts. There are pharmacies everywhere. All big cities have diagnostic laboratories, and many of them are run

privately. Animal health services are organised similarly, with clinics, veterinarians, community-based health workers, dispensaries, etc.

Mr. Chairman, Sir, What about plants, the backbone of agriculture? Try answering some of these questions. Who are the plant doctors and health workers, and where do they work? Where are the health posts or clinics and plant hospitals? Where do you send a sample from the plant to be analysed? Who recommends what to buy from Agrochemical supply shops? Are these similar to pharmacies? Farmers can get independent advice on plant health problems, but it is haphazard and irregular. Projects come and go and concentrate on a limited range of issues. Government agricultural officers have few resources and are poorly organised. Despite having officers in all States and good general knowledge of managing major problems, millions of farmers fail to get advice when needed. **A new approach is required!**

At this juncture, l wish to formally make my vision known for salvaging sick plants by establishing a unique **plant disease clinic and health system** where plant doctors and scientists will be trained. This will link extension, research, and farmers and work with all sectors to improve regular and reliable technical support and advice access. Our mission will be tagged "healthy plants for healthy people." The clinic will create durable plant health services for those who need them most, improve the advice agrochemical dealers often give farmers in their shops, increase awareness of current and emerging crop threats, reduce pesticide use, improve livelihoods, and create better food security.

Mr Chairman, Sir, I wish to inform you that Bolivia, the Democratic Republic of the Congo, Uganda, Vietnam, Sierra Leone, Bangladesh and Nicaragua have built a national plant health system based on clinics linked to reliable technical and scientific support sources. In Bangladesh, plant doctors write 'prescriptions' for eco-friendly agrochemical dealers. The extension talks to research, diagnostic laboratories, and input suppliers working with the clinics. Nigeria! Now

is the time to do it. The Federal University of Technology Minna, known for its first-class approach, must be ready to pioneer it.

Mr Chairman, Sir, fear not and be courageous; the Federal University of Technology, Minna, has competent experts in related fields in different Departments within our University. These include Mycologists(myself), Virologists, Bacteriologists, Nematologists, Horticulturists, Entomologists, Algologists, Genetists, etc. Outside the academic arena are Ministries of Agriculture and Rural Development, Farmers' Associations and Agrochemicals dealers whose knowledge, enthusiasm and imagination are a reasonable basis for running regular plant health clinics. The proposal is on its way to your table, Sir.

The challenges for plant pathology are to reduce food losses while improving food quality and, at the same time, safeguarding our environment. As the world population continues to increase while arable land and most other natural resources continue to decrease, and as our environment becomes further congested and stressed, the need for controlling plant diseases effectively and safely will become one of the most important necessities for feeding the hungry billions of our increasingly overpopulated world. Therefore, a plant clinic is inevitable.

CONCLUSION

As I am rounding up, Mr Chairman, ladies and gentlemen, today's lecture is not a question-and- answer one because I know I might have aroused many questions in my audience's mind, which I would have loved to answer, still, inaugural lecture rules have provided that immunity of ask not my anointed ones.

Mr Chairman, ladies and gentlemen, having gone this far on the expository journey of no return in the world of "mankind" and fungi relationships that give no room for either retreat or surrender, I believe that you now know that fungi are metabolic masters, earth makers, and

key players in most of life's processes. They can alter our minds, heal our bodies, and help us remediate environmental disasters. Therefore, the relationship between "mankind" and fungi is for better or worse. In this relationship, like Merlin Sheldrake (2020), I can emphatically say that Fungi make our worlds, change our minds and shape our future. Lastly, please permit me to round up this lecture by saying with a great sense of modesty that I have, along with my mentors, mentees and contemporaries in the field of Plant Pathology(Mycology), fought a good fight, I have run the race with great perseverance and have been able to mount the last rung on the academic ladder. Glory be to God.

RECOMMENDATION

1. Joint, interdisciplinary efforts of biologists, biotechnologists, pharmacists and chemists to bring a given project based on a novel fungal metabolite into the preclinics.

2. Funders from the private sector should be encouraged to invest in researchers doing essential fungi research.

3. The obstacles and challenges to the development and commercialisation of fungal biological control agents for use in controlling plant diseases, ranging from gaps in understanding the basic biological knowledge to their potential socio-economic impact, should be eradicated

4. Further studies should be conducted to determine the fungal traits responsible for the effectiveness of mycoinsecticides, enhancement of their virulence, and development of eco-friendly and effective pest management strategies.

5. Establishment of PLANT DISEASE CLINIC in the Universities and Agricultural research institutes is paramount

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BRIEF PROFILE OF THE INAUGURAL LECTURER

Prof. Matthew Omoniyi Adebola hails from Agbeku in Ifelodun Local Government Area of Kwara State and was born to the family of Elder Moses Jimoh and Mrs. Deborah Ayodele Adebola neen Afolabi. He attended Primary School at ECWA LGEA School Agbeku and proceeded to ECWA Secondary Igbaja, both in Kwara State. In search of knowledge, he moved to Kwara State College of Technology, School of Basic Studies, in 1980-1982 and the University of Ilorin, where he obtained a B.Sc.(Hons) degree Botany in 1986, M.Sc. degree in 1997 and PhD degree in 2009. He started his humble career as an auxiliary primary school teacher with LSMB in Ifelodun LGA Kwara State in 1980 after his secondary school certificate. From 1982 to 1983, after his H.Sc., he taught as one of the pioneer teachers of Government Girls Secondary School Aiyetiro-Gbede, Kogi State. He had his NYSC between 1986 and 1987 at the Federal School of Forestry, Jos. He worked with the Kwara State Teaching Service Commission as a Science Teacher from1989 to 1997. He moved to the Kwara State Local Government Service Commission as an Agricultural Officer and rose to Director of Agriculture between 1997 - 2011. He started teaching at Ekiti State University, Ado - Ekiti as a part-time lecturer at Kwara State College of Education, Ilorin and Oro centres between 1989 and 2011. He joined the services of the Ibrahim Babangida University, Lapai, in 2011 (on the transfer of service) as Lecturer I and the Federal University of Technology, Minna 2014 as Senior Lecturer on transfer of service and rose to the rank of Professor in 2020.

Professor Adebola Matthew Omoniyi has held various positions and served on many Federal University of Technology Minna committees including Post Graduate Coordinator, Department of Biological Sciences. He is the pioneer and immediate past Head of the Department of Plant Biology..

Professor Adebola has supervised and co- supervised many undergraduates,13 Master's and 18 Doctoral Theses. He has over 100

Scholarly Publications in reputable Books and Journals from his research works. He is the Author of four books. He belongs to many professional bodies including the Botanical Society: of Nigeria (BOSON), the Nigerian Society for Plant Protection, the International Research and Development Network, Nigerian Mycotoxin Awareness and Study Network (NMASN), The Research Cooperative and Mycological Society of Nigeria(MYCOSON). He is married and blessed with children.