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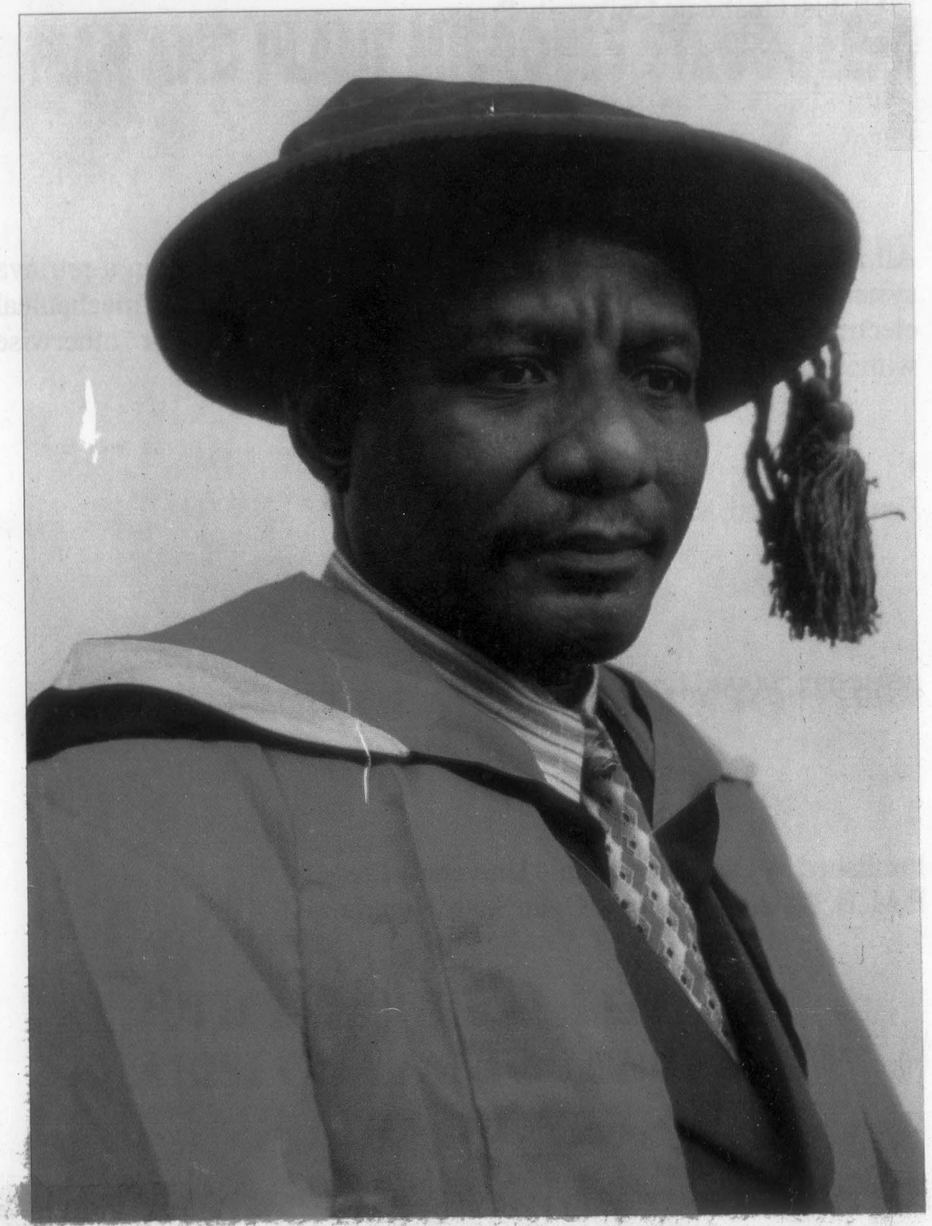

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MAN AND PLANT MICROBES STRUGGLE: A WINNER?

BY

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29TH INAUGURAL LECTURE
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AGO-IWOYE.

Tuesday, 16th March, 2004

"TO THE TEACHERS WHO TAUGHT ME
AND
THE STUDENTS WHO INSPIRE ME"

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The Vice-Chancellor,
Principal Officers of the University,
Provosts of Colleges and Deans of Faculties,
Colleagues, Friends from Sister Universities and Research Institutes,
Royal Highnesses, Chiefs, Lords: Spiritual and Temporal,
Distinguished Ladies and Gentlemen,
Great OOUITES!

I feel highly honoured to be invited, to deliver the 29th Inaugural Lecture of this great University today. It is the fifth of its series from the Faculty of Science and the third from the Department of Biological Sciences of this noble institution.

PREAMBLE

I was appointed by this University as a Lecturer I about 18 years ago necessitating the transfer of my service, from the National Horticultural Research Institute, (NIHORT), Ibadan, Nigeria. I stand before you today as a Professor, a post to which I was promoted in the year 2000 to share with you, part of my research experience to date.

My interest in the study of plants was stimulated while studying *"Nature Study"* as a subject in the Secondary Modern School in 1963. This interest was further strengthened when I offered Botany, Zoology and Chemistry as major subjects during my Higher School Certificate studies in 1970. Consequently, I was offered an admission to study Special Honours Botany at the University of Lagos for my undergraduate programme.

Broad topics covered for the then almighty June final examinations which intensified my interest further still, included Economic Botany, Plant Physiology, Mycology, Bacteriology, Microbial Physiology and Loss of crops and farm produce to microorganisms among others.

Due to my very brilliant performance at the undergraduate level, I was offered direct admission for the M.Phil. programme at the then University of Ife, now Obafemi Awolowo University, (O.A.U). My study then focussed on the survival of the water-yam anthracnose pathogen, *Colletotrichum gloeosporioides,* resulting in publications by Adebanjo, 1980, Adebanjo and Onesirosan, 1986. This marked the beginning of my interest in disease causation to plants and the difficulties encountered in the management and/or eradication of the causal agents.

The topic of my lecture - **MAN AND PLANT MICROBES STRUGGLE: A WINNER?** - is suggestive of a battle between man and plant microbes, which seems to have been consistently won by the latter. Man is the highest of God's creation and also the *Homo sapiens,* wise man while microbes are organisms, that can be seen with the aided eyes, but are found in large numbers everywhere including places like inside water, the moon, inside rocks, on ice that are not even habitable by man! In other words, both man, plants and microbes have existed side by side for several years, with man not being able to see the microbes until in the nineteeth century, but all the while seeing and experiencing the effects of their activities, especially the adverse effects which helped to draw attention to them (Kolawole,1997).

1.0 THE HISTORICAL BACKGROUND

The earliest records of man reveal that as he began to depend upon cultivated food ,feed and fibre plants for his livelihood, the problems of crop losses, food shortages, and famine continually arose to plague him. The Old Testament (Gen. 41:23; I Kings 8:37; Amos 4:9; II Chron. 6:28; Deut. 28:22; Hag. 2:16-17) made

references in the history of the ancient Hebrews to blights and mildews of the cereal and vine crops upon which the people depended heavily.

Greek Philosophers, such as Theophrastus (370-286 B.C.) noted the occurrence of crop maladies and speculated as to their cause and cure. Down through the Middle Ages, we find that scholars were impressed by the appearance of plant diseases but were quite confused as to the factors which brought them about. Scientific experiments were not common, but the occasional keen observer of nature was hampered by the current custom of explaining natural phenomena by the process of deductive reasoning. Incorrect interpretations, based on unsound analysis of facts and greatly influenced by superstition and religious dogmas, were passed from one generation to another until they became accepted as hard and fast laws of nature.

At the close of the 18th century, there was no evidence that modern concepts of the nature of disease inception in plants and the relation of environment to disease development had been adopted by those concerned with plant science and plant culture.

The invention of the microscope however, in the 17th century gave vision to the hitherto unknown world of microbes. Leeuwenhock discovered bacteria in 1675.

An Italian botanist Micheli in 1729 made an extensive study of fungi and their reproductive structures. He discovered the role of spores and experimentally proved that the fungi originated from their spores. This was the first experimental proof that fungi are autonomous organisms which produce seed-like bodies and not capricious creatures of the spontaneous generation.

On the other hand using his series of simple microscopes Van Leeuwenhock also reported the presence of minute living creatures in water from different sources and in decaying animal and vegetable matter which had been left to stand for a week or two at room temperature. Augustino Bassi in 1836 showed that the calcino disease of silkworms was caused by a fungus which invaded their tissues and could be transmitted by the inoculation of material from such tissues into those of healthy ones. These observations, together with the availability of improved microscopes, initiated the systematic description of micro-organisms.

In 1840, Henle had pointed out that a microbe causing a disease should be present in every case and should be able to produce a similar disease in animal into which it was later inoculated. These principles for establishing the causal organism of a disease were later expanded in 1870 by Robert Koch to become what are collectively called "Koch's pestulates" today. Koch and his students subsequently identified the causal organisms of tuberculosis, cholera, typhoid and many other major diseases of man and animals.

With the establishment of the link between microbes and many diseases of plants, the battle line between man and the microbes was at last clearly drawn. The nature of this battle and its present status, constitute the theme of my lecture today.

1.1 MICROBES AND PLANT DISEASES

The organisms collectively called mircobes cut across disciplines. These include the algae, protozoa, fungi, viruses, bacteria, nematodes, richettsia-like and mycoplasma-like organisms.
They are found, like I said earlier in widely diverse habitats, ranging from hot springs to human body, in soil, in air, in foods, in petroleum oil, plants, and plant produce as well as at the depths of the ocean. It was estimated that the total mass of microbes in the world is about five to twenty-five times the total mass of all life, both aquatic and terrestrial (Postgate, 1992).
It should however be noted that not all microbes are pathogenic or disease producing.

My work over the past 27 years has been mainly in the field of mycology and bacteriology and therefore, for the rest of this lecture, I shall be reporting observations made mainly on fungi and bacteria especially their involvement in plant diseases and the effort made by man to control them.

2.0 FUNGI AS PATHOGENS

Fungi pathogenic to plants are many and diverse. They exhibit greater diversity in form, function and life history than other pathogens. They have also been known as plant pathogens for a longer time than other organisms. All the major groups of fungi have important plant pathogens. Thus, *Olpidium, Plasmodiophora, Phytophthora, Pythium, Aphanomyces* and the downy mildew fungi, *(Peronospora,* and *Plasmopara)* are the best known pathogens from phycomycetes. In Ascomycotes, the powdery mildews, *Penicillium, Claviceps,* and *Monilia* cause serious plant diseases. Basidiomycetes include the elite among pathogens-the rusts, and those that transform cereal grains into nothing less than a mass of black powder, the smuts. In addition, the wood-rotting fungi *Armillaria, Fomes* and the like, have led to total collapse of wooden buildings.
The Deuteromycetes which include the *Fusarium,* the *Verticillium,* the *Rhizoctonia,* the *Piricularia* and others also cause severe ravages on plants or their produce.

Fungi have made history in all parts of the world by causing catastrophic diseases. The late blight disease of potato in Ireland, the powdery mildew of grapes in France, the chestnut disease in the USA and the coffee rust in Sri Lanka, record the temerity of only some fungi. The coffee loving people of Western Europe had to reconcile with tea. *Hemileia vastatrix* did it.

Back home here in Nigeria, the maize mildew some eight years ago or so, robbed the South West Nigerian farmers of grain harvest.

The neck and leaf blast of rice caused by *Pyricularia oryzae* was reported by Awoderu (1974). *Choanephora* leaf and panicle blight of *Amaranthus* was first reported by Adebanjo (1989). Infected inflorescence will not produce any seed. This speaker in 1985 drew attention to the incursion of the black sigatoka disease into Nigeria. Nothing was done until the disease swept the South-West, South-South and South-Eastern parts of Nigeria leading to little or zero plantain harvests for some years.

Fusarium leaf spot of *Celosia* (Sokoyokoto) and *Fusarium* wilt of tomato plants and fruit rot have been reported to significantly reduce yield in these vegetables.

Thus, fungi are ubiquitous and versatile.

3.0 BACTERIA AS PATHOGENS

It was about a hundred years ago that various workers began to realise that bacteria can cause plant diseases. Within a decade (1877 - 1887), the fireblight of pome fruits, hyacinth yellows and *mal nero* of grapevine were diseases demonstrated to be caused by bacteria. All the plant pathogenic bacteria discovered were straight or very slightly curved, rod-shaped cells with strong, rigid cell walls. Table 1 shows the major characteristics of some important phytobacteria.

Table 1: Characteristics of Important Plant Pathogenic Bacteria

Genus	Symptoms	No. of species	Gram stain	Colony colour	Motility
Agrobacterium	Galls	5	-	White	Motile
Corynebacterium	Wilt, blight canker	10	+	,,	Non-motile
Erwinia	Blight, soft rots	6	-	,,	Motile/non-motile
Pectobacterium	Soft-rot	1	-	,,	Motile/non-motile
Pseudomonas	Wilt, spots	85	-	Yellow	,, ,,
Xanthomonas	Blights, Wilt, spots	47	-	,,	,, ,,

Species in all major families of higher plants are known to be attacked by one or more bacterial pathogens.

Among fungi, the cultivated mushroom suffers from brown blotch caused by *Pseudomonas tolaasii;* among the *Pteridophytes,* a bacterial pathogen, *P. asplenii* has been reported to attack *Asplenium sp.;* among *gymnosperms* crown gall is frequently reported but there are few reports of other bacterial diseases of this group.

It is among angiosperms that most bacterial diseases have been found. The host ranges of individual bacterial pathogens vary greatly. Some are very wide e.g. *Agrobacterium tumefaciens, Pseudomonas syringae pv. syringae* and *P. solanacearum,* which all affect many genera and various plant families. Some are more restricted, such as *Erwinia amylovora,* which affects a number of genera.

The devastating effect of bacterial blight of cassava, rice and beans can hardly be forgotten in Nigeria. Similarly, pre-and post-harvest rots caused by bacteria on tomatoes, pepper, many fruits and vegetables have been widely reported in Nigeria.

Ornamentals are not spared of bacterial infection as twenty six bacteria species were isolated from woody ornamental cuttings in Nigeria (Adebanjo and Adeniyi, 1990).

4.0 POST-HARVEST LOSSES

By recognising and reducing the enormous crop losses that occur between harvesting and final utilization, a significant contribution can be made to improving the supply of agriculture/horticultural products above and beyond what may be achieved by increased primary production.

The overall post-harvest losses of durable crops including cereals, oil seeds and pulses have been established at 20% of the harvested crops in Africa, Asia and Latin America.

An FAO estimate puts losses of these commodities at 10% on a world-wide basis. In individual cases, losses are much greater and it is suggested that losses at the farm level of 30-50% followed by 10-12% in traders' stores and a further 5% in centralized stores are common. In the tropics, a conservative estimate suggests that 25% of all perishable food crops harvested are lost before they are consumed.

Even in temperate countries, perishable produce has been described as the victim of phenomenally high waste estimated at several million dollars annually.

4.1 CAUSES OF LOSSES:

The causes of losses are many including insect infestation, rodent attack, physical and pathological attack and physiological losses.

However, for obvious reasons, I will briefly discuss the pathological attack.

4.2 PATHOLOGICAL ATTACK

Attack by micro-organisms, notably fungi and bacteria is probably the most serious cause of post-harvest loss in perishable and durable produce.

All durable and dried agricultural commodities if not properly dried to a specific moisture content (14%) after harvest, are subject to attack by fungi (moulds) and to a lesser extent by bacteria. Moulds most commonly encountered include species of *Aspergillus, Penicillium, Mucor* and *Rhizopus*. Adebanjo and Shopeju (1993), in addition to the microbes above, also recorded *Rhizomucor pusillus* and *Fusarium equiseti* from sundried vegetables in storage. Also, Adebanjo (1994a) and Adebanjo and Ikotun (1994b) reported the invasion of melon and *Amaranthus* seeds respectively by fungi during storage.

Mould growth produces a number of deterioratative effects which include discolouration, production of bad odours and off-flavours, reduction in quality, and loss of viability in the case of seeds.

In some cases, highly toxic substances called mycotoxins are produced. There are many such compounds, but only a few of them are regularly found in food and animal feedstuffs such as grains and seed.

Nevertheless, those that do occur in food have great significance in the health of humans and livestock.

The effects of some food-borne mycotoxins are acute symptoms of severe illness appearing very quickly. Other mycotoxins occurring in food have longer term chronic or cumulative effects on health, including the induction of cancers and immune deficiency.

The fungal sources and mycotoxins are shown in Table 2.

4.3 ECONOMIC SIGNIFICANCE OF DISEASES CAUSED BY MICROBES:

Plant diseases caused by microbes (fungi and bacteria) have affected the existence, adequate growth, and productivity of each of cereals, tubers, fruits and vegetables, fibre crops, oil crops and ornamentals. Destruction of food and feed resources by diseases has been an all too common occurrence in the past and has resulted in malnutrition, starvation, migration, and death of people, plants and animals on numerous occasions, and these are well documented in history.

TABLE 2 *MYCOTOXINS IN STAPLE GRAINS AND SEEDS.*

Mycotoxin	Commodity	Fungal source(s)	Effects of ingestion
deoxynivalenol/nivalenol	wheat, maize, barley reported from	*Fusarium graminearum* *Fusarium crookwellense* *Fusarium culmorum*	Human toxicoses India, China, Japan, and Korea. Toxic to animals, especially pigs
zearalenone	maize, wheat	*F. graminearum* *F. culmorum* *F. crookwellense*	Identified by the International Agency for Research on Cancer (IARC) as a possible human carcinogen. Affects reproductive system in female pigs
fumonisin B1	maize	*Fusarium moniliforme plus several less common species*	Suspected by IARC as human carcinogen. Toxic to pigs and poultry. Cause of equine eicoencephalo-malacia (ELEM), a fatal disease of horses.
aflatoxin B_1, B_2	maize, peanuts, and many other commodities	*Aspergillus flavus*	Aflatoxin B1, and naturally occurring mixturesof aflatoxins, identified as potent human carcinogens by IARC. Adverse effects in various animals, especially chickens.
aflatoxin B_1, B_2, G_1, G_2	maize, peanuts	*Aspergillus parasiticus*	

Mr. Vice-Chancellor, Sir, please permit me to ask, despite the intellect and sophistication of man, these microscopic organisms are still wrecking havoc on man and indeed plants on which man and his domesticated animals are directly dependent! Are they not winning? Plant diseases resulting from microbial attacks may cause financial losses thus: farmers may have to plant varieties that are resistant to disease(s), but are less productive, more costly, or commercially less profitable than the other varieties. Farmers may have to spray or otherwise control a disease, thus incurring expenses for chemicals, machinery, storage space and of course labour. Shippers may have to provide refrigerated warehouses and transportation vehicles, thereby increasing expenses.

Mircobial induced plant diseases may limit the time during which products can be kept fresh and healthy (especially fruits, pepper, tomatoes and other vegetables), thus forcing farmers to sell during a short period of time when products are abundant and prices very low.

Some examples of plant diseases that have caused severe losses in the past are shown in Table 3.

As enumerated earlier, farmers spray crops or treat farm produce with chemicals to protect them from diseases and pests. For example, it is estimated that in the U.S. alone; each year, crops worth \$9.1billion are lost to diseases. Crop losses to diseases and pests not only affect national and world food supplies and economics but affect even more individual farmers, whether the crops are grown for direct consumption or for sale. Since operating expenditures for the production of the crop remain the same, harvests lost to diseases lower the net return.

Table 4 provides an estimate of the actual world crop production and of the preharvest losses to diseases, insects and weeds in 1982. Crop loss varies with the degree of development of the country in which the crop is produced. Thus, the estimated losses and

Table 3: Examples of Severe Losses Caused by Fungi and bacteria

Disease	Location	Comments
FUNGAL DISEASES		
1. Cereal rusts	Worldwide	Frequent severe epidemics. Huge annual losses.
2. Cereal smuts	Worldwide	Continuous losses on all grains.
3. Ergot of rye and Wheat	Worldwide	Poisonous to humans and animals.
4. Late blight of potato	Cool, humid climates	Epidemics— Irish famine (1845 - 46)
5. Brown spot of rice	Asia	Epidemics— the great Bengal famine (1943)
6. Southern corn leaf blight	U.S.	Epidemic 1970, $1 billion lost.
7. Powdery mildew of Grapes	Worldwide	European epidemics (1840 - 1850s)
8. Downy mildew of grapes	U.S., Europe	European epidemic (1870s - 1880s)
9. Downy mildew of Tobacco	U.S., Europe	European epidemic (1950s - 1960s).Epidemic in North America (1979).
10. Chestnut blight	U.S.	Destroyed all American chestnut trees (1904-1940).
11. Dutch elm disease	U.S., Europe	Destroying all American elm trees (1930 to date)
12. Coffee rust		Destroyed all coffee in Southeast Asia (1870s - 1880s).Since 1970. present in Brazil
13. Banana leaf spot or Sigatoka disease	Worldwide	Great annual losses.
14. Rubber leaf blight	S. America	Destroys rubber tree plantations.
BACTERIAL DISEASES		
1. Citrus canker	Asia, Africa, Brazil, United States	Killed millions of trees in Florida, 1910s and again in the 1980s.
2. Fire blight of pome fruits	North America, Europe	Kills numerous trees annually.

percentages of losses are considerably lower in developed than those in developing countries.

Similarly, the estimated crop production and preharvest losses (in millions of Tons) and percent lost to diseases and other pests (insects, weeds) in developed and developing countries in 1982 are as shown in Table 5.

5.0 WEAPONS OF MICROBIAL ATTACK

Although some microbes may use mechanical force to penetrate plant tissues, the activities of the microbes in plants are

Table 4: Estimated 1982 World Crop Production[a] and Preharvest Losses (in Millions of Tons) and Percent[b] of World Production Lost to Diseases, Insects and Weeds

	Actual production	Estimated losses to dis-ins-w	Potential production	Estimated losses to diseases	%of crop lost to Diseases	Insects	Weeds	Total % of crop lost
	Millions of Tons				%	%	%	%
Cereals	1,695	893	2,588	238	9.2	13.9	11.4	34.5
Potatoes	255	121	376	82	21.8	6.5	4.0	32.3
Other root crops	556	420	976	163	16.7	13.6	12.7	43.0
Sugarbeets	319	104	423	44	10.4	8.3	5.8	24.5
Sugarcane	811	991	1,802	346	19.2	20.1	15.7	55.0
Legumes	45	22	67	8	11.3	13.3	8.7	33.3
Vegetables	368	141	509	51	10.1	8.7	8.9	27.7
Fruits	302	92	394	51	10.1	7.8	3.0	23.4
Coffee-cocoa-tea	8	7	15	3	17.7	12.1	13.2	42.4
Oil crops	240	106	346	34	9.8	10.5	10.4	30.7
Fiber crops	40	18	58	6	11.0	12.9	6.9	30.8
Tobacco	6	3	9	1	12.3	10.4	8.1	30.8
Natural rubber	4	1	5	0.6	15.0	5.0	5.0	25.0
		Average percentages lost			11.8	12.2	9.7	33.7

[a] Production data from 1982 FAO Production, Yearbook (Ford and Agriculture Organization, 1982).

[b] Percentages of losses taken from Cramer (1967).

largely naturally chemical. Consequently the effects caused by microbes on plants are almost entirely the result of biochemical reactions taking place between substances secreted by the microbes and those present in, or produced by, the plant.

The major groups of substances secreted by microbes in plants that seem to be involved in production of disease, either directly or indirectly, are enzymes, toxins, growth regulators and polysaccharides.

These groups vary greatly as to their importance in pathogenicity, and their relative importance may be different from one disease to another. Thus, in some diseases, like soft rots, enzymes are by far the most important, whereas in diseases like the crown gall, toxin secreted in the plant by the pathogen causes the disease.

Enzymes, toxins, and growth regulators, probably in that order, are more common and more important in plant disease development than are polysaccharides. Generally, plant pathogenic enzymes disintegrate the structural components of host cells, break down inert food substances in the cell, or affect the protoplast directly and interfere with its physiology.

Toxins seem to act directly on the protoplast and interfere with the permeability of its membranes and with its function. Growth regulators exerts a hormonal effect on the cells and either increase or decrease their ability to divide and enlarge.

Table 5: Estimated 1982 World Crop Production[a] and Preharvest Losses (in Millions of Tons) and Percent[b] Lost to Other Pests (Insects, Weeds) in Developed and Developing Countries.

Developed countries: Population (millions): 1,186; % in Agriculture: 11.6; Arable land (millions of hectares): 672,335

Developing countries: Population (millions): 3,405; %in Agriculture: 57.6; Arable land (millions of hectares): 796,264

	Developed: Actual Production	Estim. loss to Dis-ins-W	% lost to Dis-Ins-W	MT Lost	Developing: Actual Production	Estim. loss to Dis-Ins-W	% lost to Dis-Ins-W	MT lost
Cereals	874	190	17.8	51	822	703	46.1	187
Potatoes	204	59	22.4	40	51	23	32.0	21.6
Other root crops	205	64	23.8	25	350	356	50.4	138.0
Sugarbeets	290	89	23.5	38	29	15	34.5	6.4
Sugarcane	77	40	34.0	14	734	951	56.4	332
Legumes (Dry)	12	2.5	17.2	0.8	33	19.5	37.1	6.4
Vegetables	145	43	23.0	16	223	98	30.5	36
Fruits	138	32	16	17	164	60	26.8	32
Coffee-Cocoa -Tea	0	—	—	—	8	5.9	42.4	2.5
Oil Crops	99	35	26	11	141	71	33.5	23
Fiber Crops	13	4.6	26	1.6	27	13.4	33.2	4.8
Tobacco	2	0.8	29	0.3	4	2.2	35.5	0.9
Natural rubber	0	—	—	—	4	1.3	25	0.8

a Production data from 1982 FAO Production Yearbook.
b Percentages of losses taken from Cramer (1967).

6.0 WEAPONS OF PLANT DEFENCE

In general, plants defend themselves against microbial attack by a combination of weapons from two arsenals:

1. Structural characteristics that act as physical barriers and inhibit the pathogen from gaining entrance and spreading through the plant e.g. wax, cuticle, the epidermal cell walls and the size, location and shapes of stomata and lenticels.
2. Biochemical reactions that take place in the cells and tissues of the plant and produce substances that either are toxic to the pathogen or create conditions that inhibit growth of the pathogen in the plant.

The combination of structural characteristics and biochemical reactions employed, in the defense of plants are different in different host-pathogen systems.

In spite of the preferred superficial or internal defense structures of host plants, most pathogens penetrate their hosts and produce various degrees of infection.

Plants on the other hand usually respond by forming one or more types of structures to defend the plant from further microbial invasion. Some of the defence structures are called histological defence structures and they include the formation of cori layers, formation of abscission layers and the deposition of gums. Others involve the walls of the invaded cells and are called cellular defence structures e.g. swelling of cell walls of parenchyma cells, thickening of cell wall and deposition of callose papillae all taking place to exclude the invading microbe.

Still, others involve the cytoplasm of the cells being attacked and is called cytoplasmic defence reaction.

7.0 WEAPONS OF MAN AGAINST MICROBES

I have said before in the course of this lecture that man and his domesticated animals depend on plants. I can confidently aver that on this planet, man may not survive if there are no plants. Man depends on them and many products derivable from them. There is, therefore, a need for man to eliminate the microbes or inhibit their activities to protect plants from their hamful effects. In order to do this, man has been equipped with or has developed an array of weapons against them in order to increase the quantity and improve the quality of plant products.

The various control methods are classified as regulatory, cultural, biological, physical, breeding and chemical depending on the nature of the agents employed.

(a). <u>Regulatory</u> - This control measures aim at excluding a pathogen from a host or from a certain geographic area and involves the enforcement of quarantine regulations. Experienced inspectors stationed at all points of entry into the country enforce quarantines of produce likely to introduce new pathogens. Due to human factors and act of omission on the part of the officials, this measure has not totally prevented the introduction of new diseases into places they did not exist. Some of these newly introduced diseases have been found to be severely devastating on plants in their new habitats.

(b). <u>Cultural</u> - Every cultural practice has a direct, or more often an indirect, effect on the development of diseases. On the lowest farming level, that of subsistence farming, cultural practices are, often unwittingly, the only control operations envisaged. As the level of farming rises, practices based on systematic observation and research come into use. These involve elements of sanitation debris management, tillage, choice of sowing season, soil type, topography and sowing density and moisture management. Due to meteorological and biotic factors, specific cultural practices are often locally restricted in their application. The reasons stated above, coupled with the economic aspects of cultural control, particularly if several hectrage of farmland are involved have imposed severe limitations and limited success on this method of microbial control of plant diseases by man.

(c). **Biological** - This is the total or partial destruction of pathogen populations by other organisms. It occurs routinely in nature. There are several diseases in which the microbe cannot develop in certain areas either because the soil *(suppressive soils)* contains micro organisms antagonistic to the microbe, or because the plant that is attacked by the microbe has also been naturally inoculated, before or after the microbe attack, with antagonistic micro organisms. In recent years, humans have been trying to take advantage of such biological antagonisms and have been developing strategies by which biological control can now be used effectively against several diseases. Along this direction, Bankole and Adebanjo (1996), Reported the biocontrol of brown blotch of cowpea caused by *Colletotrichum truncatum* with *Trichoderma viride*.

Similarly, the potential usefulness of *T. viride* and *Bacillus spp.* in controlling wet rot infection of cowpea caused by *Pythium aphanidermatum* was established by Bankole and Adebanjo in 1998. In 2004, Adebanjo and Bankole also evaluated and confirmed the ability of some phylloplane fungi and bacteria for biocontrol of anthracnose of cowpea. In all these our studies and those of others, some of the many problems such as:

1. ecological limitations of biocontrol;
2. the tenacity of spores or mycelia preparation of the organism(s) in that habitat;

3. finding a cheap and effective method for mass production and delivery of the antagonist and
4. the peculiar problem of foliar application particularly when tree crops are involved readily come to mind.

Unless and until some of the problems listed above and others like the expense involved are solved, biocontrol may not be regarded as an efficient, cost effective and highly dependable means of control of pathogenic infections of plants no matter the degree of success under the laboratory, greenhouse even small scale field conditions.

(d). **Physical** - The physical agents most commonly used in controlling plant diseases are temperature, dry air, unfavourable light wave lengths and various types of radiation. The limitation of this method is that it is usually restricted to laboratory and greenhouse conditions using seeds and bulbs.

(e). **Breeding** - It would be an ideal situation if we could look forward to having, ultimately, disease-resistant varieties of ALL CROP PLANTS, but, it is undoubtedly too much to expect in view of the variability of some microbes. The desire for resistant varieties is greatest in the cases of diseases which are difficult to control by other measures. To be effective, resistance to a given disease must be combined with the currently desirable agronomic characteristics of varieties, and with resistance that may have been established for one or more other diseases. Continual adjustment is then needed to meet the changing crop requirements as well as changes in the pathogenicity of the causal organism.

Breeding for disease resistance, to be applied as a control measure, therefore, must be a continuous process which is most effective when coordinated with the general improvement of the crop concerned. Unfortunately, Nigeria and indeed the whole of African

countries have not got enough scientists in this discipline not to talk of breeding for disease resistance for varieties of ALL CROP PLANTS. Apart from the personnel, the amount of money involved for a good breeding for disease resistance programme is quite enormous. I doubt if any African country can part with even a quarter of such an amount in their annual budget.
The few breeding for disease resistance programmes in Nigeria today on a fairly reasonable scale are limited to the International Institute of Tropical Agriculture, IITA, a few Research Institutes and Universities when there are funds.

(f). <u>Chemical</u> – Chemicals offer control that range from sterilization to inhibition of activities.
Chemical sterilants are usually highly reactive and damaging to living tissues.

Therefore, they require careful handling, and are applied on inanimate objects mainly. The great majority of chemicals are used for their toxicity directly to the pathogen and are effective only as protectants at the pathogens points of entry.
Chemicals that can cure plants from infections that have become established are called *chemotherapeutants* and control of plant diseases with such chemicals is called *chemotherapy*. Examples are Captafol and Iprodione.

The systemic fungicides and antibiotics are absorbed by the host, are translocated internally through the plant, and are effective against the pathogen at the infection locus both before and after infection. Examples are Benomyl and Tecto.
Although, the use of chemicals to control plant diseases looked promising initially but it is now beset with many problems some of which are:

1. non-affordability of the increasing cost of chemicals particularly by Nigerian farmers who can hardly afford to buy fertilizers,
2. lack of technical know-how and equipment for chemical application;
3. the hazards to man during application and some may have adverse genetic effects in lower organisms in the ecosystem;
4. build up of toxic chemicals that are potentially hazardous to the environment and the problem of residue on plants, fruits and seed that are consumed and
5. the build up of resistance by the microbes.

The activities of man have contributed immensely to increased resistance found among microbes. The regular use of chemicals create selective pressure on the microbial populations leading to the emergence of resistant strains.

To date *Cercospora, Penicillium, Fusarium* are a few of some fungi that have produced strains resistant to systemic fungicides.
For these and many other reasons, the use of chemical comes to mind when farmers' crops are seriously threatened particularly in Africa. The exercise may not even be economically justified by small-scale farmers.

Vice-Chancellor, in this triangular struggle/battle between man, plant and the microbes, and in spite of the formidable and sophisticated weapons of attack and defence from the combined arsenals of man and plant respectively as enumerated earlier, the pertinent question to ask is:

Are these sufficient?

Are the microbes not winning?

Under normal circumstances, plants should be able to repel or survive every microbial attack, but this is not always the case.
The equilibrum between the microbes virulence and strategies, and plant defences both natural and those imposed by man can be easily tipped in favour of the microbes in situations which predispose the

plants to infection. For example, water stressed plants or those lacking the essential micro-or macro-nutrients are easily susceptible to phytopathogenic infections.

Furthermore, poor growth conditions such as competition with weeds, pollution and water-logging would weaken the plants and so allow the microbes to multiply to such numbers that could easily overwhelm weapons of defence by plants and man's weapons of war. Therefore, plants are still infected by microbes!

By extension, if I may digress a bit to ask in a closely related case but not exactly alike, why has man not succeeded in finding a cure for AIDS since all these years?

What about man developing vaccine for the malaria microbes that have been with him for centuries scorging infants and man in tropical parts of the world?

Measles will do what it likes with children and adults in Africa till date!

We read recently from the newspapers that the Nigerian strains of the polio virus are badly hitting Beninois children.

It therefore means that the virus is still very much with us. Interestingly enough, all these diseases are caused by microbes.

I can go on and on but I would just stop at these few examples of man's inability to effectively control the microbes.

Vice-Chancellor, Sir, are we sure the microbes are not winning? I think they are winners at least for now.

At this point, the relevant question to ask is what must we do in order to have healthy plants and good yields that are well preserved?

I have the following recommendations:

i) Considering the fact that the activities of man alone have greatly contributed to the development of resistance among microbes, chemical control measures should be strictly handled or overseen by experts.

ii). I am calling on the Federal Government of Nigeria to establish a National Centre for Biotechnology to be saddled with the following responsibilities among others:

(a). Formulation of a National Policy on Biotechnological Research particularly plant biotechnologies in this case.
The application of biotechnologies to plants can contribute both to crop improvement and protection of threatened species against diseases and pests.

(b). *In-vitro* micropropagation of interesting genotypes, as well as creation of new ones through the use of somaclonal and gametoclonal variation, somatic hybridization (fusion of protoplast), directed mutagenesis and culture of haploid plants.
Furthermore, rapid cloning of species or varieties, or of selected cell or tissue strains which give high yields can be vigorously pursued thus boosting up agricultural and food production.

(c). Research in plant tissue culture which offers other advantages like production can be continuous and is not limited by season or climate. Meristem cultures can also lead to the development of tissue banks for crop varieties.

(d). The development of a new means of biological control such as pheromones, bio-insecticides, bionematicides, and selection of natural enemies of pests; the production of enzymes for the food industries and the selection of micro-organisms for industrial processes.

iii). Research for new and more effective chemicals (fungicides, bactericides) and botanicals should continue since strains of resistant microbes will continue to appear resulting from their ability to overcome each new bioagent soon after it becomes available.
The Government of Nigeria should put more money into research along this direction.

iv). The growing conditions of plants such as regular weeding, provision of supplemental micro-and micro-elements when needed and choice of a good arable land must be provided to keep potentially phytopathogenic microbes at bay.

v). A vibrant and viable extension plant pathology programme manned by experts must be put in place throughout the states of the Federal Republic of Nigeria. The experts would educate farmers on the acceptable harvesting methods, transportation and preservation/storage of farm produce to reduce post-harvest losses to the barest minimum.

Mr. Vice-Chancellor Sir, let me complete this lecture by this quotation from Agrios, 1997: about plant pathology: "During the 20th Century, plant pathology has matured as a science. Thousands of diseases have been described, pathogens have been identified, new kinds of plant pathogens have been discovered, and control measures have been developed. The studies of genetics and of the physiology of diseases have been expanded greatly, and new chemical compounds are being developed continually to combat plant diseases. Still, this is probably just the beginning of plant pathology and of the hope that it holds for the future. The huge losses in plants and plant products that occur annually are the single best reminder of *how much is yet to be learnt* about plant diseases and their control"

Therefore, Mr. Vice-Chancellor, Distinguished Guests Ladies and Gentlemen, in the likely endless struggle between man and the plant microbes, the latter seem to be consistently winning. However, it is not yet over until it is over hence the struggle continues.

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Mr. Vice-Chancellor Sir, to all here present, friends, relations, distinguished, guests, ladies and gentlemen, I thank you for listening and God bless.

Professor Afolabi Adebanjo

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