UNIVERSITY OF ILORIN

THE TWO HUNDRED AND FIFTY-SEVENTH (257TH) INAUGURAL LECTURE

"MANAGING INSECTS FOR SAFE FOOD AND LIFE"

By

PROFESSOR ABDULRASAK KANNIKE MUSA
B.Agric. (Hons); M.Sc. (Ilorin); Ph.D. (ABU)

**DEPARTMENT OF CROP PROTECTION,
FACULTY OF AGRICULTURE,
UNIVERSITY OF ILORIN, NIGERIA**

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The Vice-Chancellor

Professor Wahab Olasupo Egbewole SAN
LL.B (Hons) (Ife); B.L (Lagos); LL.M (Ife); Ph.D. (Ilorin); FCArb; Fspsp

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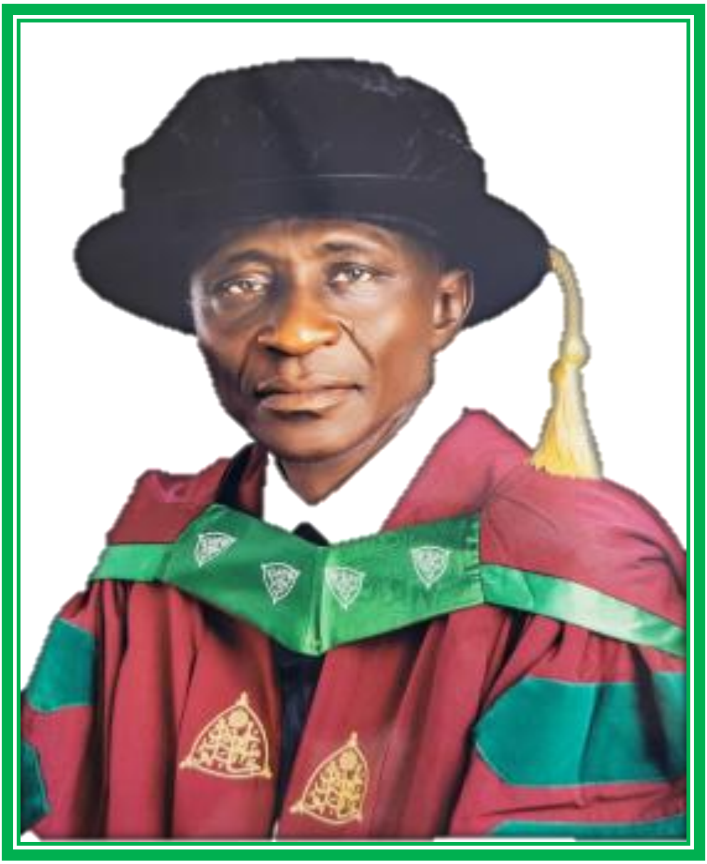

PROFESSOR ABDULRASAK KANNIKE MUSA
B.Agric. (Hons); M.Sc. (Ilorin); Ph.D. (ABU)

**PROFESSOR OF STORAGE ENTOMOLOGY,
DEPARTMENT OF CROP PROTECTION,
FACULTY OF AGRICULTURE,
UNIVERSITY OF ILORIN, NIGERIA**

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Distinguished Ladies and Gentlemen.

Preamble

It is with deep gratitude to the Almighty Allah (*Subhanahu wa Ta-alla*) that I am here today to deliver this 257th in the series of inaugural lectures of the University of Ilorin. This is the 18th in the Faculty of Agriculture, the 2nd in the Department of Crop Protection, and the 1st to be delivered by a Professor of Entomology since the creation of the Department in 2004. The 1st was the 170th inaugural lecture of this University titled, "Assuring Food Security: The Role of the Crop Protectionist", delivered by Prof. O. S. Balogun on 15th June, 2017. I had inspiration to deliver the 257th inaugural lecture from Q2:57 "And We caused a cloud to comfort you with shade and We set down upon you manna and the quails (saying): "Eat of the good wherewithal that We have provided you as sustenance".

It gives me great pleasure to welcome everyone here today. I am touched by my reminiscences about my ill treatment of insects during my childhood without regard to their enormous contributions to human survival. I had aversion to insects perceived to be constituting nuisance. Of course, most children are guilty of this misdemeanour because insects are small. Conversely, I relished eating the caterpillar of pallid emperor moth, *Cirina forda*, [*Moni-moni*] in Figure 1a and winged termite, *Macrotermes bellicosus* [*Esunsun*] in Figure 1b. Like most children, I also admired the vibrant colours and beautiful wings of butterfly, *Rhopalocera* spp. [*Labalàbà*] in Figure 2a and got attracted to and played with non-biting green fruit beetle, *Cotinis mutabilis* [*Ọbòònboòn*] in Figure 2b. Little did I know that my interaction with insects from childhood was preparatory to my becoming an Entomologist. Now, the four figures:

Figure 1(a) Pallid emperormoths

1(b) Flying termites

Figure 2(a) Butterfly

2(b) Green fruit beetle

Vice-Chancellor, sir, my interest in Entomology started after the university has granted me admission for the pursuit of Master of Science (M.Sc.) degree in the defunct Department of Crop Production. During the programme, I gained the basic knowledge in Entomology that prepared me for employment as an academic and subsequent conferment of Doctor of Philosophy (Ph.D.) degree on me by the Ahmadu Bello University (ABU), Zaria. Getting to know my three-man Supervisory Team and gaining from their wealth of experience during the programme broadened my horizons. Studying in another university benefited my career but was not without its challenges. Besides being a victim of a motor accident and robbery attack at gunpoint on separate occasions, I became stranded during a return trip following loss of two tyres of my car. I was eventually freed from the embarrassing situation by a former university classmate, Mr. A. F. Lawal (now Prof. A. F. Lawal) of Ibrahim Badamasi Babangida University, Lapai. The rest is history. *Alhamdulillahi Rabbil Al-ameen.*

Vice-Chancellor, sir, an attempt to manage cowpea beetle led to the infamous mysterious case of `killer beans` in September 1996 in Lagos, during which at least 16 victims of poisoned cowpea died. The development had untold hardship on the well-being and businesses of the people, particularly those that were selling products of beans like *àkàrà* and *moin-moin*. There were resultant effects of loss of businesses related to beans because people stopped consuming beans and bean sellers quickly ran out of business. The case was among many of wrong usage of pesticides in the management of insects in stored produce. This development led the National Agency for Food and Drug Administration and Control (NAFDAC) to publish a list of banned pesticides in Nigeria (vmap@nafdac.gov.ng; vmapnafdac@gmail.com). Unfortunately, many of them are not difficult to find in Nigerian markets.

The use of synthetic pesticides is generally associated with residue on treated agricultural produce which often exceeds the limit established for human safety. My academic endeavours in the last 25 years and three days since 6th May 1999, when I joined the services of the University of Ilorin have, therefore, been directed to providing plausible and sustainable alternatives to the use of conventional pesticides or at least minimise it against insect pests. My inspiration is to have safe food as well as healthy and active life through appropriate management of insect pests. Hence, this inaugural lecture is titled, ***"Managing Insects for Safe Food and Life".***

Introduction

Mr. Vice-Chancellor, it is necessary to have protection from pests which are living organisms that inflict injury and damage to humans, animals, plants, stored food and structures. They include arthropods (insects, mites, ticks, etc.), pathogens (viruses, fungi, bacteria, etc.), vertebrates (birds, monkeys, rodents, etc.) and weeds. They constitute threats to agriculture by transmitting pathogens mechanically (e.g., cockroaches and flies) or biologically (e.g., mosquitoes, fleas and ticks) in Figures 3a, 3b, 3c and 3d:

Figure 3a

Figure 3b

Figure 3c

Figure 3d

The entire Figure 3 falls under Arthropods (a) Tick (b) Flea (c) Cockroach (d) Mosquito

Crop Protection is concerned with management practices for crops against pests in the field and in storage. A number of management techniques including cultural, chemical, biological and host plant resistance, or a combination of these approaches, are used in reducing pest populations, particularly in the field. Crop Protection also involves provision of safe food to avoid contamination with pathogens and pesticide poisoning. A safe food does not contain any poisonous, deleterious or disease-causing substances that may render such food injurious to human health. An unsafe food is capable of causing infections which can predispose human beings to life-threatening ailments.

Vice-Chancellor, sir, Entomology as a component of crop protection, is the study of insects and related animals (mites) which infest foodstuffs in the fields and in storage, including their prevention, detection and management. Research activities on Entomology afforded me the opportunity to distinguish between the macroscopic organisms (insects) and the mostly microscopic organisms (pathogens). To the Yoruba, insects and pathogens share a common name *Kòkòrò*. Interestingly, only two out of 29 orders of insects, the Coleoptera (beetles) and the Lepidoptera (moths) are commonly found in stored produce and products.

Insects are identified with small body size divided into three regions (head, thorax and abdomen), a pair of antennae on the head, three pairs of jointed legs and usually two pairs of wings on the thorax (Figure 4).

Figure 4: Adult insect

Insects constitute the largest group of animals on earth in terms of number, with their presence recorded in almost all habitats; including land, water, air, hives, lakes, as well as plants, animals, carrions, and humans. Insects have ability to change their position by walking, crawling, flying, jumping or swimming, and adapting to any environment through camouflage, types of legs, and mouthparts. Great variations among insects are associated with morphology and modes of feeding such as predation, parasitism, herbivory, omnivory, and cannibalism. Insects are the most successful animals in causing damage to food due to their small body size, diversity, high flight capacity, great reproductive potential and survival capacity. The reproductive potential takes different forms such as oviparity, viviparity, ovoviviparity, larviparity, parthenogenesis, gonochorism, and being specialists in their diets. All these potentials enable them to improve or damage the environment.

The Need for Insect Management

Vice-Chancellor, sir, insects are among the creatures that are accorded special divine recognitions. As such, human beings need to be purposeful in their management and care. Apart from naming chapters 16 and 27 of the Glorious Quran after the Bee and the Ant, respectively, insects such as mosquitoes (Q2:26) and houseflies (Q22:73) are among the major insects that the Almighty Allah mentioned for their significance and relevance in drawing attention of mankind to His signs and majesty. Lice and locusts were also among the nine clear signs that Allah used to support the prophethood of Musa, *Alayhi Salatu waSalam* (Q7:133, Q17:101). In spite of their small size which predisposes them to being trampled upon, ants are recognized for their social nature and communication skills when Allah says, “Until, when they came upon the valley of the ants, an ant said, "O ants, enter your dwellings that you not be crushed by Solomon and his soldiers while they perceive not" (Q27:16). To underscore the significance of the bee as a major species of insects which have implications for human nutrition including access to safe food and general human survival, the Almighty Allah says, "And your Lord inspired to the bee, "Take for yourself among the mountains, houses, and among the trees and (in) that which they construct. Then eat from all the fruits and follow the ways of your Lord laid down (for you). There emerges from their bellies a drink, varying in colours, in which there is healing for people. Indeed, in that is a sign for a people who give thought" (Q16:68 – 69).

Most people are more aware of the damage and diseases transmitted by few insects than the beneficial role of most insects. There are early references to the use of insects in daily life. These include growing of mulberry silkworm, *Bombyx mori* that began in 4700 BC in China for the production of natural silk. Also, the collective responsibility of honey bees in the production of honey is a natural lesson that humans would go places if we could do things in the spirit of teamwork. In spite of this, certain insects have health, economic, environmental and sustainable development impacts.

The negative effects of insects are generally exacerbated by climate change and pesticide resistance. Mosquitoes and tsetse flies are responsible for transmitting malaria and sleeping sickness, respectively. Termites have the ability to damage wooden structures in homes, offices and farms through their feeding activities. Locusts are serious and dangerous insect pests of grain crops, particularly when they swarm in their millions. The negative impacts of postharvest insect pests include grain weight loss, grain damage, loss of quality and decrease in the commercial value of grains. These challenges threaten the attainment of food security as pointed out by **Musa** (2012). Appropriate insect management of stored products may involve sanitary strategies, air-tight storage (hermetic), and modification of storage conditions are, therefore, necessary in reducing postharvest losses caused by insect pests and mitigating environmental hazards.

Insect management also impacts on the achievement of the Sustainable Development Goals aimed at reducing poverty and hunger. Most insects, including honey bee (*Apis mellifera* L.), serve as sources of food or are used to boost agricultural productivity through pollination. However, increased food preservation and supply of nutritious food that is free from insect pests and contaminants are required to guarantee food security. Other edible insects include ants, honey bees, beetles, grasshoppers, caterpillars, wasps, locusts, cicadas, grubs, and mantises. Honey bees provide products such as beeswax, and propolis as sources of income.

Insects also have potential as bioindicators of environmental pollution or contamination. Insects that feed on agricultural pests are called natural enemies, including praying mantis, lady bugs and wasps. A number of flies, ants and beetles feed on carrion thereby helping in sanitation and ecological balance. Insects are also useful in experimental studies.

Management Practices for Storage Insects

Use of Pesticides

The use of insecticides was first recorded in 4500 years ago by Sumerians who used sulphur compounds to control insects and mites (Unsworth, 2010). Pyrethrum is obtained from the dried flowers of the *Chrysanthemum cinerariaefolium,* and has been used as an insecticide for over 2000 years. Between 1870 and 1945, people began to use inorganic synthetic materials and since then, people have been using inorganic pesticides to control many pests. With the advent of synthetic pesticide, dichlorodiphenyltrichloroethane (DDT) in the mid-1940s, its excessive application, misuse and abuse in agriculture resulted in chemical hazards. Application of chemical pesticides affects non-target organisms and impacts on the environment, and thereby paved the way for increase in insect pest population.

The effects of conventional pesticides on stored-product insects include pesticide resistance, toxic residues in the treated products, handling hazards, health hazards and pest resurgence. Pesticides are associated with high cost, and require technical know-how and skills to safe use on the part of peasant farmers.

Improper use of pesticides has led to chemical poisoning, and loss of lives. The global concern for use of pesticides due to associated environmental hazards, adverse effects on non-target organisms and eco-toxicity, development of resistance to chemicals by insect pests and presence of residues in food has evoked regulatory restrictions on the use of chemicals for insect pest control (Umoetok *et al*. 2009; Nwosu & Nwosu, 2012). There is a great limitation in the effectiveness of synthetic chemicals against insect pests of stored products. The most alarming resultant effect of chemical abuse is pesticide resistance. It is interesting that chemists, physiologists, agriculturists, and pharmacists derive a common front in discussing the need to source alternative approach to the use of toxic pesticides, thereby adding appreciative value to the significance of insect management for safe food. According to Database of Arthropods Resistant to Pesticides (DARP, 2003), stored-product insect pests were found to be resistant against several insecticides.

Use of Plant Materials

There is a global call for shift to the use of a more appropriate and environment-friendly protection strategy against pests. Plant powders, plant oils, phytochemicals and plant extracts otherwise called botanicals are safer candidates that can be used to protect stored grains against insect infestation. These botanicals keep stored seeds safe for planting, as well as human and animal consumption. Botanicals have low toxicity and are biodegradable, making them acceptable for formulation. Stored grains preserved with plant parts had increased shelf life compared to unprotected grains which showed holed grains, powdery mass of the grain and loss of aesthetic quality. Spices such as ginger, garlic, African nutmeg and cloves contain some compounds with insecticidal components, having the potential to serve as alternatives to synthetic pesticides. Powder and extract formulations of the spices are common and provide the best alternative to the use of pesticides.

Insect Management for Safe Life

The desire of man to live a safe life can be influenced through his interaction with insects. Insect interactions with man include serving as pests, vectors of diseases, sources of food/feed, medicine, and tools for scientific studies toward human and animal health. Insects have proved useful in many industries like food, cosmetics, and agriculture. The action of insect pests can lead to contamination of agricultural produce with their body parts, exuviae, eggs, and off-odours. In spite of this, a number of substances useful against infections are derived from insects. These include anti-microbial peptides, apitoxins, fatty acids, and enzymes.

In relation to public health, insects are well-known for their role as vectors of pathogens or diseases. Insects can transmit several infectious pathogens which may ultimately results in mortality. In order to protect people from the negative effects of insects as pests, and vectors of diseases, extensive efforts are often deployed to the management and control of insects using pesticides. For all pesticides to be effective against the pests they are intended to control, they must be biologically active, or toxic. Because synthetic pesticides are toxic, they are also potentially hazardous to humans, animals, other organisms, and the environment. This is because most pesticides that are resistant to microbial degradation can accumulate in human body and the environment causing problem to human health. Therefore, people who use pesticides or regularly come in contact with them must understand the relative toxicity, potential health effects, and preventive measures to reduce exposure to the products they use. Public health authorities have therefore set specific standard requirements for insect management using different strategies, including identification of the insect vectors and implementation of cultural, mechanical, chemical and biological control measures. It is important to note that none of the hazardous effects of synthetic pesticides are associated with the use of plant materials and products which have formed the focus of my research.

My Research Contributions to Knowledge

Vice-Chancellor, sir, I have focused my research on management of field and storage insect pests using plant products, and insect-resistant crops for increased crop productivity, improved food preservation. safe food, life and enhanced environmental sustainability. This inaugural lecture therefore, considers three specific areas that I have worked on. These are Storage Entomology, Environmental Entomology, and Agricultural Entomology.

Use of Plant Materials against Field Insect Pests

Vice-Chancellor, sir, **Musa** *et al*. (2023) investigated the possibility of using onion bulb and tobacco leaf extracts against insect pests and yield components of cowpea in the field. The responses of flower thrips, *Megalurothrips sjostedti* Trybom, the pod-sucking bug, *Clavigralla tomentosicollis* Stal, the pod borer, *Maruca vitrata* (F.) and cowpea aphid, *Aphis craccivora* Koch. were studied. The plant treatments were applied at 10% (w/v) while synthetic insecticide (Cypermethrin) was applied at 1 L per ha, including the untreated control. Results revealed that cowpea treated with the plant extracts had significantly lower insect pest population than cowpea in the untreated plots. Tobacco leaf extract produced significantly heavier 100-seed weight than other treatments. It was found that the plant extracts had potential to replace Cypermethrin by reducing insect population on the cowpea and ensuring environmental safety.

Trials conducted by Yusuf and **Musa** *et al.* (2022) examined the efficacy of ethanol extracts of teak, *Tectona grandis* and almond, *Prunus dulcis* leaves against sweet potato weevil (*Cylas puncticollis*) and flea beetle (*Phyllotreta cruciferae*) infesting sweet potato. The various treatments employed were single applications of almond and teak leaf extracts at 15% and 25% concentrations. Mixed application of almond and teak extracts at varying proportions, Cypermethrin (0.15%) and the untreated control were included. Mixed applications of teak and almond leaf extracts were more effective than single applications and lowered the population of the insect pests to a level comparable to Cypermethrin. It was found that the combination of teak and almond leaf extracts applied at 25% w/v recorded the least number of both sweet potato weevil and flea beetle. Also, teak and almond leaf extracts were found to contain secondary metabolites in different concentrations (Table 1). The plant extracts had the potential for use in controlling sweet potato weevil and flea beetle. Many farmers earn additional income by collecting and selling plant parts for use against insect pests

Table 1: Quantitative phytochemical constituents of ethanol extracts of almond and teak leaves

Compounds	Almond leaf (mg l^{-1})	Teak leaf (mg l^{-1})
Tannins	0.52	0.50
Saponins	3.15	2.99
Flavonoids	0.36	1.01
Phenols	0.44	0.63
Alkaloids	1.38	1.29
Glycosides	6.24	6.73
Terpenoids	0.10	0.13
Oxalates	0.98	1.02

Mr. Vice-Chancellor, the pests attacking ornamental plants in the Federal Capital Territory (FCT) Abuja, Nigeria were studied by Oyerinde, **Musa** *et al*. (2017). Abuja has six Area Councils which are Abaji, Bwari, Gwagwalada, Kuje, Kwali and Abuja Municipal Area Councils (AMAC). The study identified and assessed pests infesting ornamental plants collected from three purposively selected Area Councils in the FCT (Abuja Municipal Area Council, Gwagwalada Area Council and Kuje Area Council). Pests present in samples of faunas collected from farms and gardens include termites, ants, grasshoppers, aphids, mealy bugs and snails. Farmers agreed on the incidence of termite infestation on their farms in all the Area

Councils, while they also observed that the foliage and flowers were the most attractive parts of ornamental plants to pests. Roots were mostly preferred by soil-dwelling pests as habitats to meet their nutritional needs. The pests encountered were classified into nine orders of insects and one order of mollusc, including Coleoptera, Orthoptera, Hymenoptera, Heterocera, Homoptera, Hemiptera, Rhopalocera, Diptera, Blattodea (Isoptera) and Stylommatophora. It was found that Gwagwalada Area Council had the highest number (13) of pests while Kuje Area Council had the least number (8) of pests on the ornamental plants.

Tomato plays an important role in human diets being a source of nutrients and lycopene. Whitefly (*Bemisia tabaci*) infestation of tomato causes damage during feeding and transmits viruses, thus impacting serious threat to agriculture. In Nigeria, the pest has caused loss of tomato quality and dwindling value in the supply chain, particularly in urban centres. In an effort to solve the problem, Mustapha, **Musa** *et al.* (2022) assessed vertical farming of tomato which favoured increase in population of predatory spiders suppressing whitefly population from 6–10 weeks after transplanting. The vertical farming of tomato in cities is, therefore, a plausible alternative to traditional farming. Vertical farming ensures year - round production and more efficient use of space.

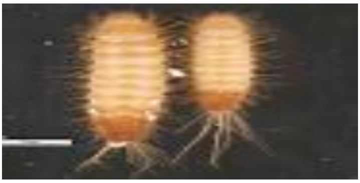
Adekola, Akpan and **Musa** (2012) evaluated the effect of varying hormonal treatments and length of cuttings of clonal materials on the sprouting and rooting abilities of *Jatropha curcas* L. Two stem cuttings, 30 cm and 60 cm long, were treated with Naphthalene acetic acid (NAA) and Indole-3-Butyric acid (IBA) at 100, 150 and 200 mg per litre, including the untreated control. It was found that cutting length and hormone concentration had significant effect ($p<0.05$) on survival, sprouting number of leaves, and rooting behaviours of *J. curcas.* The 60 cm cuttings performed better than 30 cm cuttings in terms of sprouting, rooting and plant biomass accumulation. The untreated control showed better development than those treated with NAA and IBA. The 60 cm cuttings performed better when untreated with hormone while 30 cm cuttings performed best when treated with IBA at 200 mg per litre. It was concluded that 60 cm untreated cuttings could be used for large scale propagation of *J. curcas.*

Balogun, Aliyu and **Musa** (2013) carried out a survey in 2011 and 2012 to evaluate the perception of “Fadama” III farmers in the 16 Local Government Areas of Kwara State on pests using flexible semi-structured interview survey method. The most widely planted crop was maize (72.2%), while 18.3% and 10% of respondents believed that insects and diseases were the most important pests responsible for yield reduction. Two-third of the respondents were aware of Integrated Pest Management (IPM) and a large majority (82%), claimed to practice it. The study concluded that under environment-friendly atmosphere, IPM knowledge by “Fadama” III farmers could ensure improved agricultural productivity in Kwara State, Nigeria.

Use of Plant Materials against Storage Insect Pests

Vice-Chancellor, sir, stored agricultural produce are often infested by insects, suggesting the need for their control. Cowpea beetle (*Callosobruchus maculatus* Fabricius) is a primary pest of stored seeds of pigeon pea, soyabean, bambara groundnut and African yam bean. Maize weevil, *Sitophilus zeamais* Motschulsky is a primary pest of cereals, including maize, rice, sorghum, millet and wheat. Khapra beetle, *Trogoderma granarium* Everts larvae (Figures 5a to 5e) are serious pests of legumes, cereals and animal products. In the quest for alternatives to the use of toxic pesticides against these pests, plants have been touted to be promising candidates for being non-persistent and not leaving behind long-lasting residues. Application of plant materials against the pests will reduce cases of food poisoning and environmental contamination associated with pesticides. These insect pests are:

Figure 5a Cowpea beetle 5b Maize weevil 5c Khapra beetle (Adult)



5d Maize grain infested by maize weevil

5e Khapra beetle (larvae)

Use of Spices

Mr. Vice-Chancellor, spices are seeds, fruits, roots, used as ingredients in food. Spices contain compounds like polyphenols which help preserve food by acting as natural antioxidants, thereby slowing down the process of spoilage. In Nigeria, maize (*Zea mays* L.) which is processed into *Ogi*, *Akamu* or *Eko* and consumed by people of all ages, is often infested by maize weevil, *S. zeamais* in storage. **Musa** and Lawal (2019) used four spice powders (African nutmeg, garlic, clove and ginger) in the control of adult maize weevil in stored maize (var. SAMMAZ 52). It was found that mortality of the insect increased with period of exposure in various concentrations of the spice powders. Highest concentration of garlic and clove powders caused total mortality of the insect and inhibited oviposition within 5 days of treatment. No adult maize weevil emerged from the spices at 3% rate of application throughout the period of the study. Maize grain treated with ginger and clove powders suggested that their insecticidal properties matched the efficiency of Permethrin dust. It was found that inclusion of the spice powders in insect management would avoid problems of resistance and food poisoning associated with the Permethrin.

Cowpea (*Vigna unguiculata* Walp.) is another commonly consumed food throughout the country. The seeds are rich in proteins, fibres, vitamins, and minerals, but usually infested by cowpea beetle, *C. maculatus* in storage. **Musa** (2012) investigated the protective potential of root bark powder of candle wood tree, *Zanthoxylum zanthoxyloides* (Linn.) (*Orin-ata*). The powder was applied at the rates of 5, 7 and 10 g per 150 g cowpea grain and the mixture was thoroughly agitated to ensure even spread of the powder. Ten pairs of adults of *C. maculatus* were introduced into each container. The root bark powder reduced grain weight loss and grain damage of cowpea by 3.72% and 11.76%, respectively compared to the control over a period of three months ($p < 0.05$). The root bark powder offered storage protection of cowpea. The responses of *C. maculatus* to *Z. zanthoxyloides* were concentration and time-dependent.

Use of Plant Powders

An understanding of the impact of the use of plant powder on insect infestation of stored agricultural products and the quality of food is crucial for food security in the country. The effectiveness of plant powders was tested against khapra beetle, *T. granarium* larvae in stored groundnut. **Musa** and Dike (2011) used *Khaya senegalensis* Desr. seed powder for the control of khapra beetle, *T. granarium* larvae in stored groundnut. Highest concentration of the powder at 7% consistently gave the least groundnut weight loss of 3.7%, 8.0% and 13.0% at 1, 2 and 3 months after the treatment, respectively ($p < 0.05$). It was found that the plant powder had the potential for use in the control of the beetle. Similarly, **Musa** (2013) found that powders of both *Moringa oleifera* leaf and *Allium sativum* clove caused 86.6%

mortality of adult *T. granarium* when applied at 6%, suggesting their insecticidal potential against the beetle.

Musa *et al*. (2009) investigated the synergistic potentials of bitter leaf, *V. amygdalina* and basil, *O. gratissimum* leaf powders on cowpea grain infested with cowpea beetle, *C. maculatus*. The mixture of the leaf powders was evaluated at different ratios at 5% per 30 g cowpea infested with the insect. The study concluded that the mixture of the two plant powders at 1:1 caused significantly higher mortality of cowpea beetle, least egg count and reduced number of emerged insects than the untreated control. Similarly, **Musa** and Adewale (2015) compared the protective capacity of bitter leaf, cashew leaf, orange peel and pawpaw leaf powders against cowpea beetle in stored cowpea. These were tested at 2.5%, 5.0%, and 7.5% (w/w) for their insecticidal activities against *C. maculatus.* Bitter leaf and orange peel powders at various rates of application gave significantly lower cowpea grain damage of 5.3-5.7% and 6.3-11.0% within three months of food storage, respectively.

Use of Plant Extracts/Oils

Vice-Chancellor, sir, the culinary nature, medicinal and bioactive properties of vegetable oils aroused my interest in their utilisation against insect pests, and led to my first publication exactly 25 years ago. **Musa** and Adetunji (1999) studied the daily mortality responses of *S. zeamais* to changes in rates of groundnut, soyabean and olive oils to ascertain the most effective vegetable oil and time of exposure for total mortality effect and to provide baseline period of exposure. Also tested were the efficacy, persistence and viability of the vegetable oils against the insect in stored maize (var. DMSR-Y). The highest rate of the vegetable oils at 10 ml kg^{-1} grain gave 93-100% mortality of the insect on day 2 of exposure. F_1 progeny was, however, not significantly different with the different oils. Groundnut oil inhibited oviposition more than either soyabean or olive oil at 10 ml per kg dosage. The potency of all the vegetable oils decreased at different rates with time. The insecticidal activities of the vegetable oils were found to be dependent on rates of application and exposure period. The ability of the oils to exert negative influence against the insect conferred storage protection; the vegetable oils could serve as required agents in the formulation of biopesticidal compound against insects.

Mr. Vice-Chancellor, maize weevil would continue to be a contributory factor to food insecurity unless appropriate steps are taken to control the insect. For that reason, **Musa** *et al*. (2011) evaluated the toxic effect of *Jatropha curcas* seed oil on maize weevil, *S. zeamais* in stored grain. At the end of 4-month storage period, the Weevil Perforation Index (WPI) ranged between 17.91 and 26.32% in the various treatments investigated. **Musa** and Adeleye (2013) reported the insecticidal activities of *J. curcas* seed oil against *C. maculatus* (F.) in stored cowpea. A Soxhlet extractor was used for the extraction of the seed oil in 4 h using petroleum spirit as the solvent. Eight pairs of live *C. maculatus* were introduced into each unit containing 50 g seeds. *Jatropha curcas* seed oil was applied at the rates of 0.2, 0.3, 0.5 and 1.0 ml/50 g cowpea seeds while the untreated control and solvent-treated seeds were included. The highest rate of treatment was not significantly ($p > 0.05$) different from 0.5 ml, both of which gave between 98.4 and 100% adult mortality of *C. maculatus* within three days of treatment. The effects of the plant extracts were, however, significantly different from the solvent-treated and untreated seeds throughout the period of study. It was found that the potency of the *J. curcas* seed oil reduced with increasing exposure period.

Musa and Adeleye (2013) also carried out an evaluation of the repellent potential of *J. curcas* seed oil. *J. curcas* seed oil treatments were applied at 0.2, 0.3, 0.5, and 1.0 ml to one-half of the filter paper while petroleum spirit served as diluent. A significantly higher repellency was achieved at higher rates than lower rates of treatment. An average number of 3 insects was repelled in the highest concentration compared to 4 – 6 insects recorded in the lower concentrations. The results indicated the ability of *J. curcas* seed oil to induce mortality and repel C.

maculatus in stored cowpea. Adequate post-harvest protection of cowpea seeds could be achieved by incorporating the *J. curcas* seed oil in pest management techniques. was capable of reducing weevil infestation.

In a related development, the efficacy of *J. curcas* seed oil on another stored-product insect, *C. maculatus* in cowpea was examined. It was found that the seed oil gave excellent performance by causing 92.2% mortality of the beetle within 48 hours of exposure. Babatunde and **Musa** (2020) carried out a study that examined the efficacy of n-hexane extract of *Eucalyptus globulus* leaf against cowpea beetle, *C. maculatus* on cowpea (variety RSH 256). The extract was tested at dosages of 50, 100, and 150 µL per 50 g of cowpea grain. It was found that the extract caused adult mortality of the insect, reduced adult emergence and suppressed weight of cowpea seeds damaged ($p < 0.05$). The *Eucalyptus* oil at 150 µL/50 g cowpea gave the highest mortality and lowest progeny emergence. The grain treated with 150 µL per 50 g cowpea grain recorded the highest mortality and lowest emergence while the untreated control had the lowest mortality and the highest insect emergence. The rates of application were indicative of bioactive characteristics of the plant extract. Usman, Olanipekun, Ogundele and **Musa** (2016) tested the contact toxicity of essential oil from fresh and dried leaves of *Citrus meyerii* against *C. maculatus*. There was no significant difference in the insecticidal activities of the essential oil against the insect on a 6-hour basis. At the end of 42 – hour of exposure, oils from the fresh and leaves dried for one day caused 85% mortality while there was 95% mortality of *C. maculatus* for the leaves dried for two, three and four days, respectively.

Khapra beetle, *T. granarium* is an insect that hampers the preservation of groundnut and competes with man for its protein and other nutrients. In a study on groundnut kernels, **Musa** (2007) estimated that kernel weight damage ranged between 10 and 25% in storage. Subsequently, **Musa** *et al*. (2009) used *Hyptis suaveolens* Poit as a biodegradable and safe alternative for the protection of cowpea against khapra beetle.

Musa and Lawal (2016) examined the insecticidal activity of ethanolic extracts of orange (*Citrus sinensis*) leaf and peel, and locust bean tree (*Parkia biglobosa*) leaf and seed for preservation of groundnut against khapra beetle. The locust bean tree seed was found to cause significantly higher mortality (70% at 96 hours after treatment) of the insect`s larvae than other plant parts. The insecticidal activities of the plant extracts were linked to the secondary metabolites detected in the plant parts, including saponins, alkaloids, steroids, tannins, cardiac glycosides, flavonoids and phenols. Seed extract of locust bean tree (*P. biglobosa*) gave the least percent groundnut seed damage and seed weight loss, as well as higher seed viability. It was also found that locust bean tree seeds proved to be most promising control approach for further development as botanical formulation for use against khapra beetle.

Musa *et al*. (2007) tested the effects of methanolic extracts of the leaves of *Ricinus communis*, *Hyptis suaveolens*, *Annona senegalensis*, and seed of *Xylopia aethiopica*, and *Khaya senegalensis* against larvae and adults of *T. granarium* in stored groundnut. Each plant material was tested at three concentrations of 1.0 ml, 2.0 ml and 3.0 ml per 50 g and evaluated on three replications. Mortality of adults and emergence of *T. granarium* were significantly ($p < 0.05$) increased and reduced, respectively by all doses of the crude extracts compared to the untreated control. The plant extracts had considerable potential for use in post-harvest management of *T. granarium* in stored groundnut.

Screening of Crop Varieties for Resistance to Insect Pests

Vice-Chancellor, sir, improvements have been made in the development of insect-resistant crops. Resistant crops are known to possess heritable characteristics to fill the gap of combining the high yielding varieties with resistance to insect pests. Such resistant crops are safe and offer human and environmental safety. In addition, the development of insect-resistant crop varieties will reduce food losses and cost of preservation. **Musa** *et al*. (2006) evaluated the relative susceptibility and preference of six groundnut varieties to the khapra beetle, *T. granarium* infestation. The groundnut varieties: SAMNUT 14, SAMNUT 18, SAMNUT 21, SAMNUT 22, ICGV-IS-96894 and ICGV-IS-96855 released for use by the Institute for Agricultural Research, Samaru, Zaria were investigated. Two varieties, SAMNUT 22 and ICGV-IS-96855, had the highest and lowest weight loss within 6-month storage period, respectively. It could be mentioned that one variety (ICGV-IS-96855) was resistant to the khapra beetle for having least mean weight of kernel damage, and larval population at the end of the study. In the same study, measurement of the body length of the *T. granarium* larvae showed significant differences ($p < 0.05$) in varieties SAMNUT 18, SAMNUT 21, SAMNUT 22 and ICGV-IS-96894.

Cassava (*Manihot esculenta* Crantz) is a major root crop that serves as source of energy for the teeming population. Based on its nutritional value, Adekola, Affinnih, **Musa** *et al*. (2014) investigated the susceptibility of five cassava cultivars to cassava green spider mite in Ilorin. It was found that the cultivars had varying degrees of severity to the pest. A local cassava cultivar, *Odongbo* had the least cassava green spider mite severity of damage which was at par with TMS 92/0326 and *Oko-Iyawo* cultivar. Cassava green spider mite symptom was higher with TMS 92/30572 than other cultivars ($p < 0.05$). The fact that TMS 92/0326 recorded a low pest severity score, suggests that it could be recommended to farmers in the agro-ecological zone for cultivation. In addition, host-plant resistance could be adopted as alternative means to the control of pests instead of using pesticides.

Screening for cowpea varietal resistance was used to manage *C. maculatus* in stored cowpea. **Musa** and Adeboye (2017) studied the responses of seven cowpea varieties to the seed beetle, *C. maculatus*. It was found that seed weight damage and weight loss were low in one variety, IT89K-288, compared to other varieties. In a related study, Raymond and **Musa** (2018) screened improved cowpea varieties for resistance to *C. maculatus* and found that one of the varieties (IT10K-866-1) was highly resistant to the insect. The source of resistance was identified to be antibiosis. Similarly, Bankole, **Musa** *et al*. (2022) carried out an assessment of resistance of 23 cowpea genotypes to *C. maculatus* and found that one genotype, IT07K-125-107, offered a degree of resistance based on least number of emerged beetle and weight loss. These resistant cowpea varieties showed reduced threat of cowpea beetle and could therefore be released to farmers for cultivation and subsequent preservation.

Mr. Vice-Chancellor, **Musa** (2005) assessed the resistance of maize varieties to maize weevil, *S. zeamais* and obtained varying degrees of responses. Popcorn exhibited possession of heritable characteristics that reduced seed damage and weight loss by the insect pest (Table 2).

Table 2: Mean number of damaged seeds and weight loss of maize varieties infested with *Sitophilus zeamais*

Varieties	**Mean No. of seeds damaged ± SE**	**Mean Weight loss ± SE**
Pop corn	2.12 ± 0.53	1.88 ± 0.18
SUWAN-LSR.Y	3.55 ± 0.44	2.06 ± 0.09
DMR-ESR.Y	4.14 ± 0.15	2.36 ± 0.03
DMR-LSR.W	4.69 ± 0.11	2.36 ± 0.03
$LSD_{(0.05)}$	1.43	0.37

Popcorn variety was less susceptible and therefore, recommended for cultivation by farmers. **Musa** *et al*. (2018) found two maize genotypes (2008 SYN-EE W DT STR and 2004 TZE-W-POP STR C4) to be resistant to the insect. The resistant genotypes had the least weight loss, grain damage and number of emerged adults and therefore, suggested to be incorporated in integrated approach against *S. zeamais*. Another study by Olufade, **Musa,** Bankole *et al.* (2019) evaluated maize weevil, *S. zeamais* resistant potential of 10 local maize varieties and 27 intervarietal crosses. It was found that reduced number of emerged adults, low seed weight and the phenolic content (183.09–191.70 mg GAE/kg) conferred resistance in the seven crosses to the insect.

Food Safety

Mr. Vice-Chancellor, the importance of packaging for food safety cannot be overemphasised. However, packaged food such as biscuits are susceptible to rust red flour beetle, *Tribolium castaneum* Herbst. **Musa** and Lawal (2013) carried out an investigation of 10 different brands of biscuits which showed that inadequate packaging could lead to significantly high number of rust red flour beetle and weight loss within three months of storage.

Essential oils have great potential as biopesticides. Karim, **Musa** *et al.*(2017) examined the essential oil composition of seeds of maize, soybean, pumpkin, and lemon. The major compounds found in the seeds were oleic acid (32.08%), 1.9 – tetradecadiene (46.52%), ethyl oleate (48.46%) and d-limonene (20.50%) in maize, soybean, pumpkin and lemon, respectively. The bioactive components of nutritional and industrial values identified in the seeds included monoterpenes, sesquiterpenes, aldehydes, acids, esters and oxides, thus their use as biopesticides is not hazardous to human health and non-target organisms.

Quality of Life

Mr. Vice-Chancellor, environment is an independent factor that affects human survival and life. Quality of life which represents the expectation and concern for one's own health and life (Chang et al., 2020) is affected by the presence of heavy metal and contamination in the environment. Considering the fact that honey is produced by female worker bees using nectar collected during their foraging activities, heavy metals in honey samples can help in predicting the safety of the environment for human survival and life. Honey samples can therefore be used as bioindicators for the presence of heavy metals in the environment and food. Given that heavy metals concentration higher than the standard recommended for consumption is a serious health concern, honey is also useful in the detection of contaminants to check for negative anthropogenic influences.

Mustapha, **Musa,** Ojumoola and Orijemie (2023) analysed heavy metals in honey samples collected from 10 locations of the rainforest and savannah vegetation zones of Nigeria using spectrophotometer. The samples indicated significant variations in the concentrations of heavy metals among different locations such as Fe, Cu, Cd, Cr, Mn, Zn and Ni. Honey sample collected from one location had Ni concentration slightly above the maximum residue limit (MRL) of 0.02 mg/kg. Another location had the highest amount of Fe detected at 1.48 mg/kg which was above the MRL of 1.00 mg/kg. Fe and Mn were observed to be prevalent in seven and four different locations, respectively. Cu and Zn were observed to be prevalent in one location each. Cd, Cr and Ni were the least of heavy metals observed in the honey samples collected from different locations.

Furthermore, Mustapha, **Musa** *et al*. (2023) used honey to determine the level of contamination of agricultural crop as a sustainable alternative to random and expensive sampling in the rainforest vegetation zone of Oyo State, Nigeria. A total of 20 honey samples were collected from four apiaries. The pollen analysis of the honey showed that oil palm had the highest pollen count of 51,488 and was the most predominant crop foraged on. Fe (0.040 mg/kg to 0.213 mg/kg) was detected from various parts of the oil palm (Table 3).

Table 3: Heavy metal contaminants of vegetative and reproductive parts of oil palm

Oil palm	**Iron (mg/kg)**	**Manganese (mg/kg)**
Leaves	0.213 ± 0.174^a	0.116 ± 0.080^a
Flowers	0.141 ± 0.109^b	0.219 ± 0.199^a
Kernels	0.040 ± 0.035^b	0.051 ± 0.030^a
Pulp	0.071 ± 0.059^b	0.036 ± 0.021^b
Honey	0.106 ± 0.126^b	0.058 ± 0.097^a

Values with the same superscript in the same column are not significantly different from each other ($p < 0.05$).

The leaves showed significantly ($p < 0.05$) higher concentration of Fe than other parts. Flowers, leaves and kernels showed significantly higher concentrations of Mn than the pulp. In spite of the contribution of honey bees to the promotion of healthy environment, honey production is faced with a number of challenges. Lawal, **Musa** *et al*. (2023) examined the challenges faced by beekeepers in the major beekeeping locations in Oyo State, Nigeria. It was found that theft was the most serious constraint of beekeeping followed by herder`s issue (53.8%), bush burning (36.3%) and indiscriminate use of pesticides (20.5%).

Lawal, **Musa** *et al.* (2023) investigated the effect of raffia baskets, plastic bowls and Ziploc bags on quality of tomato fruits between 1 and 7 days of storage. Food utilisation is affected by food quality. Total ash content dropped from 1.90 to 1.32% while the pH content increased from 1.09 to 4.45 after 7 days of storage ($p < 0.05$). The dry matter content varied from 6.93 to 7.96% ($p<0.05$). Tomato fruits stored in raffia basket, plastic bowls and Ziploc bags had moisture content of 92.13%, 93.07% and 92.7% at 7 days of storage, respectively. For efficient storage, plastic bowls were considered the best storage container for improved shelf life of tomato fruits.

Community Service and other Administrative Responsibilities

Mr. Vice-Chancellor, I have successfully supervised numerous undergraduate projects, 15 M.Sc. dissertations, and five Ph.D. Theses while I have been appointed as External Examiner for both undergraduate and postgraduate programmes for some universities. I have served as a tutor in Agricultural Science at the University of Ilorin Joint Universities Preliminary Examinations Board (JUPEB) since its inception in 2017/2018 to 2021/2022 academic session.

My appointment as Ag. Head of Department between 2014 and 2017 afforded me the opportunity to collaborate with hard-working members of the department and faculty for a successful completion of my tenure. Previously, I had served as Departmental Undergraduate Examinations Coordinator, Seminar Coordinator, Secretary at departmental meetings and Departmental Postgraduate Coordinator. While I am currently serving as the Chairman of the Faculty Advancement Committee, I have had the privilege of serving as Chairman, Faculty of Agriculture Committee for 2021 National Universities Commission Programmes Accreditation Exercise for which, with the support of the Management, the Dean, and members of staff, the B. Agriculture, B.Sc. Food Science, B.Sc. Home Economics, and B. Forestry programmes obtained the full accreditation status.

I have also served as Chairman, Committee on Lecture Halls/Classrooms and Laboratories Management, with satisfactory accomplishments of set goals and objectives. Similarly, I have had the opportunity to serve as Chairman, Technical Committee for 2022 Promotion Exercise in the Faculty. I have also served as Faculty Representative on Postgraduate School Board, as well as Faculty of Agriculture Representative on the Board of Clinical Science.

Being a member of the University of Ilorin Plantation Committee afforded me the opportunity to work with other team members in the maintenance and management of citrus, cashew, date palm, teak, Jatropha and oil palm plantations. I was a member of the Editorial Committee of the Journal of Agricultural Research and Development (JARD), Farm Practical Training Committee and others.

Vice-Chancellor, sir, as a member of the Unilorin 1988 set of old students of Faculty of Agriculture, I played active role at both the 30th anniversary and reunion programme held at the university on Saturday, 18th August 2018 where items worth one million naira (₦1,000,000) were presented to our alma mater and shared among all Departments on the B. Agriculture programme, and the get together held on Tuesday 8th February 2022 where fish hatchery, deep borehole, metal scaffold and plastic tanks were donated to the Faculty.

Having served as the Secretary, Balogun Gambari Youth Movement, and a major stakeholder in the entire Kannike Dynasty, I am currently working in collaboration with academics from my community to support the establishment and implementation of the Initiative for the Promotion of Quality Secondary Education (IPQSE) for members of Balogun Gambari community.

Conclusion

Vice-Chancellor, sir, plants are essential natural and renewable resources that are available to farmers and capable of purifying the environment. The use of locally available plant and edible materials, particularly spices, is effective in preservation against insect pests, and extending the shelf life of stored food. An overall improvement in nutritional status of food and environmental safety can, therefore, be achieved with management of insect pests using plant powders, plant extracts and insect-resistant crops.

Application of appropriate insecticidal plants will also enable the farmers or other stakeholders to achieve food free from hazards and limit contaminants within the critical control points. It is, therefore, important to manage insects for all to have safe food and life. As an ardent advocate for the use of alternatives to toxic chemicals in insect management, I will not rest on my oars until there is the guarantee for safe food, life and sustainable environment.

Recommendations

Mr. Vice-Chancellor, achieving safe food, life and sustainable environment requires that:

1. the use of plant materials, insect-resistant crops or integrating plant resistance with low dosages of synthetic insecticides are taken as appropriate insect management practices, and are not resort to outright kill-all-syndrome that has eaten deep into the fabric of traditional agricultural system;
2. farmers and other major stakeholders in the food system should acquire necessary pesticide education for controlled use of synthetic pesticides and encouraged to incorporate the application of botanical insecticides in the management of insects for safe food and life;
3. there is support for advocacy on the incorporation of formulated botanical insecticides in insect management among all stakeholders;
4. government through NAFDAC, the Competition and Consumer Protection Commission (CCPC)and other relevant agencies, strengthen food safety legislation, monitoring and enforcement of maximum residue limits of pesticides on food items;
5. government funding for research activities is increased in order to cover for the high cost and long period required for the development of new resistant crops;
6. insect museums should be established in each of the geopolitical zones of the country to aid insect identification for effective insect management, training and teaching of students; and
7. established forest or tree plantation should be managed and maintained to ensure continuous supply of plant materials for use as botanicals.

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I appreciate the Vice-Chancellor, Prof. W. O. Egbewole, SAN, for the approval to deliver this inaugural lecture. May the Almighty Allah help you realise your aspirations for the University. I thank other Principal Officers of the University: Prof. O. A. Omotesho, Deputy Vice-Chancellor (Academic); Prof. S. F. Ambali, Deputy Vice-Chancellor (Management Services); Prof. A. A. Fawole, Deputy Vice-Chancellor (Research, Training and Innovation); Barrister M. A. Alfanla (Registrar) and Dr. K. T. Omopupa (University Librarian).

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