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Enhancing Africas Environmental Management: Integrated Pest Management for Minimization of Agricultural Pesticides Pollution

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ABSTRACT

Although, agriculture remains the means of mans procurement of his foremost basic need (food), pests struggle with him for most essential agricultural yield, thereby channeling his resources to colossal waste. Worldwide, about one-third of the agricultural products grown by humans are consumed or destroyed by insects. Pests also threaten mans life by spread of lethal diseases. Man responds to this challenge in physical, chemical and biological pests control measures. Pesticides which are predominantly used in Africa, are not only unspecific, unnatural and unsustainable but also pollutes environment, thereby increasing the challenges to Africas environmental management. This study reviews agricultural pest control measures and recommends the Integrated Pest Management (IPM) as well as some post-harvest protection measures for agricultural yield in African countries into which the flow of pesticides and fertilizers has been enhanced in the era of globalization.

Key words: Environmentally unsustainable pesticides, food security, agricultural waste, alternative pest management

INTRODUCTION

Agriculture is indisputably the maiden occupation of man. The early man began to hunt to kill and eat animals, fishes and birds. He later began to domesticate some of them. He also depended for food and sustenance on wild plants that grew in his environment. As he dropped nomadic habit for sedentary lifestyle, he began to domesticate some crops by cultivation (Uguru, 2010).

Agriculture is still the mainstay of most economies in the world. Animal husbandry and crop production have since become mans answer to his food needs. In the past 100 years, agriculture has expanded from the subsistence practice-a typical family producing its own food, fuel, farm animals, fertilizer, tools, shelter and most of its clothing, disposing of small surplus quantities, if any, in the market-to the commercial practice by which a typical family produces its own food, fuel, farm animals, fertilizer, tools, shelter and most of its clothing, disposing of much more surplus quantities of these in the market. Specifically, agriculture is now classified as subsistence when less than 25% of the gross yield is sold as surplus in non-rural market while the rest is channeled to satisfying household needs and as commercial, when more than 75% of the yield is sold while less than 25% is consumed by the household. Sub-classes are the semi-subsistence, when between 25 and 50% yield is sold as surplus while the rest is consumed by the household and the semi-commercial, when about 50-75% yield is sold as surplus while the rest is consumed by the household (Shreve and Brink, 2002; Uguru, 2010).

Agricultural yields, at both subsistence and commercial scales, are decimated by pests, operating on the plants and animals in the field as well as on the post-harvest stores. This unacceptable development channels mans resources to colossal waste. It is estimated that about one-third of the agricultural products grown by humans are consumed or destroyed by insects worldwide. Mosquitoes carry yellow fever, malaria and other diseases. The Black Death (or Pneumonic Plague or Bubonic Plague) of the middle 14th century which claimed 25 million European lives (25% of the European population at the time) was contracted from rat bearing a bacterium, *Yesinia pestis* (Shreve and Brink, 2002; Eneh, 2005).

Therefore, progress both in agriculture to meet mans foremost basic need of food and in health to ensure mans freedom from vectors, dictates pest control. Pests are controlled physically, chemically and biologically. Physical control has serious constraint of limited scale while the biological control is yet to gain wide practice. The chemical control practice which employs pesticides, has permeated the world. Although, pesticides and fertilizer are mostly manufactured in the developed world, they are widely used in Africa for both subsistence and commercial agriculture (Shreve and Brink, 2002).

In the era of globalization, the movement of pesticides and fertilizer into Africa is grossly facilitated. For example, the values of chemical and allied products imports increased in Nigeria by 213% from N123 billion in 2003 to N385 billion in 2007 on average annual increase of 43% (NBS, 2007, 2008). Nigeria constitutes one-fifth of Africas population. Parts of these products are pesticides and fertilizers. Thus, the disadvantages of using them are brought to bear on the continent. Most of the disadvantages centre on environmental pollution and degradation which pose serious challenges to sustainable development of the continent because some of the more common air, soil and water contaminants are fertilizers, pesticides and chemical substances/elements.

Africas environment and rich natural resources need to be carefully managed. Destruction of Africas air, soil and water environments needs to be minimized in agricultural practices by limiting the use of fertilizers, pesticides and chemicals in favour of biological pest control which is natural, environmentally friendly and sustainable. This study reviews agricultural pest control and recommends the Integrated Pest Management (IPM) as well as some post-harvest protection measures for agricultural yield. After this brief introduction, the rest of the study is structured as follows: Pest, havoc by pest and pest control measures; pesticides and pollution; Integrated Pest Management (IPM); post-harvest preservation of farm yields and conclusion and recommendations.

Pest, havoc by pest and pest control measures: A pest is an unwanted life form, injurious to human, animal or crop. It could be alga, fungus, bacterium, insect, rodent, nematode and herb etc. It is unwanted in livestock and crop farms and needs to be gotten rid of, in order to improve agricultural production and preservation of farm yields (Uguru, 2010; USA EPA, 2009).

Pesticides are pest killers and chemical agents used for pest control. They can be classed according to the type of pest they control. Table 1 lists pests and their pesticides (pest killers).

Pesticides are also grouped as chemical pesticides (derived from a common source or production method), biopesticides, antimicrobials and pest control devices. Examples of chemical pesticides are organophosphate pesticides and carbamate pesticides which affect the nervous system by disrupting the enzyme that regulates acetylcholine, a neurotransmitter. Most organophosphates are insecticides. They were developed during the early 19th century but their effects on insects which are similar to their effects on humans, were discovered in 1932. Some are very poisonous (and were

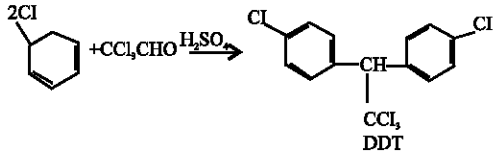
Table 1: Some pests and their pesticides

Pest	Pesticide
Herb (weed)	Herbicide (weedicide)
Insect	Insecticide
Rodent	Rodenticide
Mite	Miticide (acaricide)
Alga	Algicide
Fungus	Fungicide
Bacterium	Bactericide
Nematode	Nematicide
Microorganism	Biocide
Egg (of insect and mite)	Ovicide
Snail and slug	Molluscicide

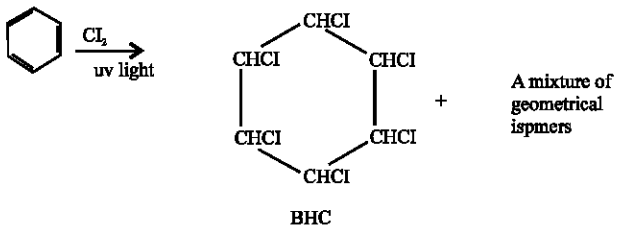
Sources: Shreve and Brink (2002) and USA EPA (2009)

used in World War II as nerve agents). However, they usually are not persistent in the environment because they are degradable. The enzyme effects are usually reversible. There are several subgroups within the carbamates (USA EPA, 2009).

Other examples of chemical pesticides are organochlorine insecticides and pyrethroid insecticides. Organochlorine insecticides were commonly used in the past but many have been removed from the market due to their health and environmental effects and their persistence or non-degradability (e.g., Dichlorodiphenyltrichloroethane, DDT and chlordane). DDT is a broad-spectrum insecticide capable of cheap production by acid-catalysed condensation of chlorobenzene and chloral (Tedder *et al*., 1975; Eneh, 2007, 2000).



Encouraged by the success of DDT, a spate of industrial research led to the development of a series of chlorinated hydrocarbon insecticides, including hexachlorocyclohexane (BHC) (Tedder *et al*., 1975).



Pyrethroid pesticides were developed as a synthetic version of the naturally occurring pesticide pyrethrin which is found in chrysanthemums. They have been modified to increase their stability in the environment. Some synthetic pyrethroids are toxic to the nervous system (USA EPA, 2009).

Biopesticides are certain types of pesticides derived from such natural materials as animals, plants, bacteria and certain minerals. For example, canola oil and baking soda have pesticidal

applications and are considered biopesticides. Biopesticides fall into three major classes: Microbial pesticides, Plant-incorporated-protectants (PIPs) and biochemical pesticides (USA EPA, 2009).

Microbial pesticides consist of a microorganism (e.g., a bacterium, fungus, virus or protozoan) as the active ingredient. They can control many different kinds of pests, although each separate active ingredient is relatively specific for its target pest (s). For example, there are fungi that control certain weeds and other fungi that kill specific insects. The most widely used microbial pesticides are subspecies and strains of *Bacillus thuringiensis* (Bt.) Each strain of this bacterium produces a different mix of proteins and specifically kills one or a few related species of insect larvae. While some Bt's control moth larvae found on plants, other Bt's are specific for larvae of flies and mosquitoes. The target insect species are determined by whether the particular Bt produces a protein that can bind to a larval gut receptor, thereby causing the insect larvae to starve (USA EPA, 2009).

PIPs are pesticidal substances that plants produce from genetic material that has been added to the plant. For example, scientists can take the gene for the Bt pesticidal protein and introduce it into the plants own genetic material. Then the plant, instead of the Bt bacterium, manufactures the substance that destroys the pest (USA EPA, 2009).

Biochemical pesticides are naturally occurring substances that control pests by non-toxic mechanisms. Conventional pesticides, by contrast, are generally synthetic materials that directly kill or inactivate the pest. Biochemical pesticides include substances, such as insect sex pheromones, that interfere with mating, as well as various scented plant extracts that attract insect pests to traps (USA EPA, 2009).

Pesticides also include Antifouling agents that kill or repel organisms that attach to underwater surfaces, such as boat bottoms; Antimicrobials that kill microorganisms (such as bacteria and viruses); Attractants that attract pests (for example, to lure an insect or rodent to a trap, excepting food which is not considered a pesticide when used as an attractant); Biopesticides derived from such natural materials as animals, plants, bacteria and certain minerals; Disinfectants and sanitizers that kill or inactivate disease-producing microorganisms on inanimate objects; Fumigants that produce gas or vapor intended to destroy pests in buildings or soil; Microbial pesticides which are microorganisms that kill, inhibit or out compete pests, including insects or other microorganisms; Pheromones which are biochemicals used to disrupt the mating behavior of insects and Repellents that repel pests, including insects (such as mosquitoes) and birds. The term, pesticide, also includes Defoliants, Desiccants, Insect growth regulators and Plant growth regulators. Defoliants cause leaves or other foliage to drop from a plant, usually to facilitate harvest. Desiccants that promote drying of living tissues, such as unwanted plant tops; Insect growth regulators that disrupt the molting, maturity from pupal stage to adult or other life processes of insects; Plant growth regulators which are substances (excluding fertilizers or other plant nutrients) that alter the expected growth, flowering, or reproduction rate of plants (USA EPA, 2009; Eneh, 2007).

Herbicides can be selective, sparing some classes of weeds and killing others; or total herbicide which kills all plants to which it is applied. They are often applied using manual or motorized sprayer (University of California Prep, 2009; Uguru, 2010).

Insects have consistently been the worlds foremost opportunists. They have populated the land and the fresh waters with the greatest assemblage of species than any other group of organisms. Insects are everywhere and seem to endure with a unique kind of indestructibility. This underlies not only the continued struggle between insects and humans for food and shelter but also the human fight against insect-transmitted diseases (Shreve and Brink, 2002).

Insecticides are agents or preparations for destroying insects. Historically, the use of insecticides dates back to 1000 B.C. They were more often useless than useful because they were based on legend and superstition, rather than on scientific knowledge. The essential property of early insecticides was a disagreeable odour, rather than a poisonous nature (Shreve and Brink, 2002). It was more scaring than lethal, more crude than specific (USA EPA, 2009).

Insecticides are frequently classified according to their mode of action. Stomach insecticides are lethal by ingestion, while contact insecticides kill by external bodily contact. The fumigants which emit poisonous vapours, kill through the respiratory system. Insecticides may be applied as spray, if liquid; in suspension, if dust; or as gas. Systemic insecticides are absorbed and translocated throughout the plant. Thus, they render plants toxic to aphids, red mites and other sucking insects that are notoriously hard to kill (University of California Prep, 2009; USA EPA, 2009; Shreve and Brink, 2002).

Rodents are notable pests. They eat crops in the field or farm and grain that people have worked hard to grow, harvest and store. They do not just eat grain, they spoil it by urinating and defaecating on it. A rat family can grow to more than 1.000 in size in just one year. Between 10 and 25% of all grain produced in developing countries is eaten or spoilt by rats. Rodents also spread diseases in many ways. The urine of many rats carries *spirochaete* bacteria called leptospire which survive in damp surroundings and infect people, cattle and other domestic animals through cuts and wounds. Once in the body, the bacteria damage the liver and kidney, sometimes causing death. This disease is known as leptospirosis or Weils disease (Outreach No. 31, 1995).

Some disease-ridden fleas and mites live on rat bodies and pass diseases on to man. Examples are typhus and bubonic plague, carried by the fleas of black rat. Rat-spread diseases have killed more people than all human wars. Rat bites people at night while they are asleep. The bites are nasty, causing scars and infections and occasionally leading to death (Outreach No. 31, 1995; Eneh, 2005).

Rats live everywhere, except deserts. City life is best for rats, especially in hot weather. Rats like to live where people live together in crowded conditions where drainage and sewage services are poor and where rubbish piles up. In parts of India and Africa, there are about 10 rats for every human being. In 1983, all waste disposal and cleaning services were withdrawn from cities in Libya. By the end of 1984, the country had 8 cases of bubonic plague (Outreach No. 31, 1995).

Rats can knaw their way through hard wooden blockages and easily burrow through piles of rubbish. They can climb poles or trees from which they can jump to their target 60 cm away (Outreach No. 31, 1995; Eneh, 1998).

Rodenticides are bated with rice, cereal, fishmeal, cornmeal and bread. They can be fast acting or slow-acting. The former kills fast and the rats suspect only after many of their relatives have died as a result of taking the bated poison. The slow-acting ones are more sneaky, since rats do not die as soon as they eat them. Even the smarted old rats are fooled. Traps are also used against rats. Rat guard is also helpful in keeping rats away (Outreach No. 31, 1995; Eneh, 1998).

Miticide or acaricide is the chemical agent used to control mite, while algicide is the chemical agent used to control alga. Fungicide is the chemical agent for the control of fungus, while bactericide is the chemical agent used to control bacterium. Nematicide is the chemical agent used for the control of nematode. Biocide is the name for a group of chemical agents used to control microorganisms. Ovivide is the name applied for a group of chemical agents for the control of eggs (of insects and mite). Molluscicide is the chemical agent for the control of snail and slug (USA EPA, 2009; Shreve and Brink, 2002; Eneh, 2007).

Pests could also be controlled mechanically by physically killing the pests and removing their eggs/larvae/cocoons by hand or biologically by use of the enemies (predators, parasites and pathogens) of the pests. Killing pests one at a time by hand is not good enough, especially when the pest population is high or in commercial agriculture. Other methods of pest control are cultural, legal and environmental control. Cultural control adopts crop rotation and other techniques. Legal control might involve the isolation of a pest-infested area to prevent further spread of pests. Environmental control may involve changing the environment, including physical control with structure, temperature control (insects die at 0°C or below if exposed for a long time and are kept away at 5°C) and sanitation control which involves good housekeeping practices (Outreach No. 31, 1995 and No. 32, 1995; Willson, 1985).

Pesticides and pollution: According to the module of the University of California Prep (2009), El-Saeid *et al.* (2010), Al-Wabel *et al.* (2010), Tabieh and Al-Horani (2010) and Al-Turki (2010), pesticides can bioaccumulate (e.g., they concentrate in specific plant and animal tissues and organs) or accumulate in the soil if their structures are not easily broken down in the environment. The persistence of pesticides in the soil is related to how quickly these chemicals degrade in the environment, usually by biodegradation, chemical degradation and photochemical degradation. Microorganism activity plays the predominant role in the biodegradation of pesticides. Water plays an important role in the chemical degradation of pesticides (e.g., some pesticides are hydrolyzed on the surfaces of minerals by water). Exposure to sunlight can also degrade some pesticides. Besides rendering the soil toxic to other living organisms, these pesticides may leach out into the groundwater, polluting water supplies (University of California Prep, 2009; Eneh, 2011).

Chlorinated hydrocarbons, such as DDT are highly toxic in birds and fishes but have relatively low toxicity in mammals. They persist in the environment, lasting for many months or years. Because of their toxicity and persistence, their use as insecticides has been somewhat restricted. There is growing documentation of the harm pollution is inflicting on wildlife. The pesticide DDT was banned in the U.S. in 1972 because it caused raptor eggs to thin and break. But, residual DDT and other persistent organochlorine pesticides continue to impact wildlife today. Additionally, DDT is still used in many other countries as the most effective control of malaria-bearing mosquitoes (University of California Prep, 2009).

Organophosphates, such as Malathion, are more poisonous than other types of insecticides but have much shorter residence times in the environment. Thus, they do not persist in the environment and cannot bioaccumulate. Carbamates, such as Sevin are generally less toxic to mammals than are organophosphates. They also have a relatively low persistence in the environment and usually do not bioaccumulate. Botanicals, such as camphor are derived from plant sources. Many of these compounds are toxic to mammals, birds and aquatic life. Their persistence in the environment is relatively low and as a result bioaccumulation is not a problem. Synthetic botanicals, such as Allethrin, generally have a low toxicity for mammals, birds and aquatic life but it is unclear how persistent they are and whether or not they bioaccumulate (University of California Prep, 2009).

Most herbicides do not persist in the soil for very long. Contact chemicals are applied directly to plants and cause rapid cell membrane deterioration. One such herbicide, Paraquat received notoriety when it was used as a defoliant on marijuana fields. Paraquat is toxic to humans but does not bioaccumulate. Systemic chemicals, such as Alar are taken up by the roots and foliage of plants and are of low to moderate toxicity to mammals and birds; some systemic herbicides are highly toxic

to fishes. These compounds do not have a tendency to bioaccumulate. Soil sterilants, such as Diphenamid, render the soil in which the plants live toxic. These chemicals have a low toxicity in animals and do not bioaccumulate (University of California Prep, 2009).

Protectant fungicides, such as *Captan*, protect the plant against infection at the site of application but do not penetrate into the plant. System fungicides, such as *Sovran* are absorbed through the plants roots and leaves and prevent disease from developing on parts of the plant away from the site of application. Fungicides are not very toxic and are moderately persistent in the environment (University of California Prep, 2009).

Integrated pest management (IPM): Many pesticides work well for only a short time. They soon get resisted by pests and become ineffective. Now, malaria is more of a problem than it was many years ago because between 1970 and 1980 the number of insects (including mosquitoes that carry malarial parasites) that became resistant to insecticides almost doubled. In Africa, about half of all children under the age of three years are infected and a million die each year (Outreach No. 30, 1995).

Most pesticides are not selective. Many insecticides kill beneficial insects and pest predators along with the insect pests. Of the several million kinds of insects on earth, only about 10.000 kinds are pests. Thus, it is foolish and costly to spray insecticides all over our environment. On account of non-biodegradability, some pesticides move through food chains to harm fishes and birds and prove poisonous to man when he consumes the poisoned plants and animals. Many pesticides seep into the soil, contaminating ground water supplies, lakes, rivers and food and drink sources. And many persist for a long time, poisoning the environment for hundreds of years (Outreach No. 30, 32, 1995).

Based on the foregoing disadvantages, the use of pesticides (chemical poisons) is not the best way to control pests. Hence, pest control by use of pests of pests is now encouraged. These natural enemies of pests are specific in action, attacking only one kind of pest. They are true pesticides, killing only the pest we want them to kill. They are also cheap or inexpensive and natural. In Nicaragua, they are reared in a laboratory and then released to attack pests. They are 3Ps: predators, parasites and pathogens. The predators kill and eat pests. The parasites live on/in pests and may also kill them. The pathogens cause diseases in pests. The praying mantis is an example of pest predators, though it also eats useful insects. The ladybird does a better job of eating pests. Some small wasps are pest-killing parasites. They lay their eggs on the bodies of plant-eating insects. After a wasp larva hatches from each egg, it grows by feeding on its insect host. Pathogens are usually bacteria or viruses. One kind causes milky spore disease which kills the Japanese beetle. The cat is popularly used against rat. This new way of pests control forms part of a programme called Integrated Pest Management, IPM (Outreach No. 30, 1995).

Post-harvest preservation of farm yields: The use of chemicals for preservation of crop yields during storage has become common, with the attendant pollution and poisoning of humans and wildlife. Hence, it is now encouraged that farmers should preserve crop yields after harvest without the use of chemical agents. This could be achieved by keeping grain from heating in storage and from moisture (which causes grain to heat). Also, from heat (which encourages insect attack) and away from heat and moisture (which make grain to get mouldy). Again, away from rodents (which eat and spoil it by defaecating on it) and mixing ashes with the grain (Outreach No. 31, 1995 and No. 70, 1996; Eneh, 2007).

CONCLUSION

Of all occupations of man, Agriculture is the oldest and most pervading. It provides food, a foremost basic need of man, without which he would die off. But, pests struggle with man for most essential agricultural yield, thereby rubbishing mans efforts, agricultural inputs, time and other invaluable resources. Agricultural losses are not restricted to the farm or field but also extend to the produce during storage. In other words, damage is not only done by pests to the plants in the farm or field but also to the harvested foodstuffs being stored for consumption and/or opportune sale. Pests also threaten mans very existence by spread of diseases.

Pests must not be allowed to have their way. Rather, pests are controlled physically, chemically and biologically but most preferably, by Integrated Pest Management (IPM). The Nicaragua project that rears pests of pests (predators, parasites and pathogens) in the laboratory and then releases them to attack specific pests should be replicated in all African countries, since none of the countries can do without agriculture and since this practice is inexpensive, natural and specific in action. Since the use of chemical agents to preserve farm harvests pollutes the environment and poisons man, farmers should adopt natural means of preservation of crop yields during storage. These are keeping grain from heating in storage, from moisture (which causes grain to heat), from heat (which encourages insect attack), away from heat and moisture (which make grain to get mouldy), away from rodents (which eat and spoil it by defaecating on it) and mixing ashes with the grain.

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