APPLICATION OF MICROBIAL INSECTICIDES AS ALTERNATIVE TO THE ENVIRONMENT- POLLUTING INORGANIC INSECTICIDES

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Abstract

One of the scientific measures man has taken to combat food shortage in an attempt to adequately feed the ever-increasing human population is the application of insecticides among other pesticides to enhance agricultural production and produce storage. Insecticides have also been used to control insect disease-vectors of man and animals such as mosquito, tsetse fly, cockroach etc. The application of toxic "chemical" insecticides for this purpose may cause the environmental problem of water and air pollution due to their non-biodegradability as well as the likely consequence of their / biomagnification along the food chain. Biotechnology has been used to develop *microbial insecticides which are genes or proteins obtained from certain microorganisms.* The application of microbial insecticides in agriculture and disease- vectors control is very effective and has little or no adverse environmental impact. The aim of this paper is to advocate the mass production and application of microbial insecticides as alternatives to chemical insecticides to ensure a clean and healthy environment.

Introduction

Microbial insecticides are chemicals that are made from microbes and are used in controlling insect pests. Insects are of agricultural importance. There are two categories of insects of agricultural importance.

These are the beneficial and the harmful insects. The beneficial insects are those that help in pollinating crops. For example the butterfly and the honeybee. The honeybee produces honey, which is medicinal and nutritive to man. Some insects are used to control weeds. For example the prickly pear ***(Opuntia inernus and Opuntia stricta)*** which threatened to take over Australia in the 1920s was controlled by introduction of the Argentinean moth ***(Cactoblastic cactorum).***

Another example is the control of prickly pear of South Africa, ***Oputia fiscus-indica*** by the cochineal insect ***Dectylopius puntide*** (Fullick, 1994).

Harmful insects are insects that are referred to as pests. Some cause damage to economic crops e.g. locust, while some are vectors of human and animal diseases. There is need to check the number and the activities of these insects before they get to economic threshold. Insect pests are most commonly controlled using synthetic insecticides, which unfortunately are very expensive, scarce, toxic to man and animals, and also may result in biomagnification in the environment.

Synthetic insecticides are also massively used to control insect pests such as mosquitoes, tsetse flies, cockroaches and termites. There are myriad formulations, which come as aerosols, powder or in liquid forms. Their application leads to environmental pollution in most cases.

Microbes Useful as Insecticides

Biotechnology has been used in the production of proteins from some microbes for the control of insect pests. These pest-killing microbes include bacteria, which have been selected or modified to kill insect pests. For instance the protein content of the crystal form of the microbe, ***Bacillus thuringensis*** has been discovered to be pathogenic to the larvae of a very wide range of insects belonging to the ***Lepidoptera.*** The insect-killing toxin genes of Bt often found in diseased insects or in soil or plant debris, have already been successfully transferred to some plants, to protect them against insect attack. The un-engineered bacteria (Bt) and ***Bacillu sphaericus*** are already being widely used as sprays to kill pests in forestry and agriculture. They are also used to kill the larvae of blackflies, the vector of river blindness, in the World Health Organisation's West Africa Onchocerciasis Control Programme (OCP), (Walgate: 1990). Although the B proteins are highly toxic to insects, they have been reported to be harmless to people and animals, which digest them like any other proteins (Samson, 1987).

Other insecticidal protein of microbial origin includes *Chitinase.* These are enzymes that attack and destroy *Chitin*, the main component of the hard part of insects. They are produced by several bacteria of the genera ***Seratia, Streptomyces and Vibrio,*** and by some fungi. Locust can be controlled with fungal *Chitinases*. Some ***Bacilus sphaericus*** strains have proved very effective against malarial mosquitoes.

Advantages of microbial insecticides

i. They are cheap and simple to produce. This is because they are naturally occurring organisms and are abundantly present everywhere. Bacteria cultures are simple to make and so sprays can be made locally. Up to one third of the dry weight of the culture bacteria can be pure crystalline toxins.

ii. They are non-toxic to man and animal although this claim has to be confirmed for each new variety of toxin developed.

iii. They are selective, specific and harmless to useful organisms.

iv. Insects lack good resistance mechanism to the bacteria toxin according to present evidence, compared with the resistance they can develop to synthetic insecticides which has been a serious matter for the **OCP (onchocerciasis control programme).**

v. The use of the protein of **Bacillus thuringensis** as insecticide is 80,000 times more powerful than the organophosphate insecticide commonly sprayed on crops. (Taylor, Green and Stout; 1997).

Biotechnological Improvement of Microbial Insecticides

Microbial insecticides have been obviously improved and produced by the application of biotechnology- specifically Genetic Engineering Techniques.

Bacteria themselves can be applied to crops as a form of biological control of insect pests, but this is rather expensive because they quickly die, making regular spraying necessary. With the application of biotechnology, attempts are being made to isolate just the toxins and to stabilize them by protein engineering. A more cunning approach is to take the gene responsible for the production of toxins and to genetically engineer it into plants, giving them permanent protection. Caterpillars or other larvae eating their leaves would die. This has been attempted and successfully achieved for some plants. For instance maize is attacked by the European com borer, an insect larva that tunnels into the plant from eggs laid on the undersides of leaves. In field trials, normal and genetically engineered maize plants were deliberately infested with larvae and- the results monitored over 6 weeks. The average length of the tunnels in the engineered plants was 6.3cm and in the normal plant was 40.7cm (Taylor, Green and Stout: 1997).

The application of biotechnology has made it possible to produce this toxin in large scale. The objective of genetic engineering of pest pathogens is to increase the virulence of existing pathogens creating super pathogens, which are much more effective at attacking the insect pest.

The other thrust of genetic engineering is to introduce genes from insect pathogens into plants so that when an insect feeds on the plant, it also takes in a dose of toxin. Genes from **Bacillus thuringiensis** (Bt) have been introduced into various crop plants, including cotton, potatoes and tomatoes.

Biological pest control has been reported to have excellent safety record, with over 4000 introductions of exotic agents against insects and 1000 against weeds worldwide and with no major accidents, Stringent safety measures are normally applied when introducing totally new and alien genetic material into the environment. (Walgate, 1990).

Large-scale production of microbial insecticides (toxins) is easily **realizable because microorganisms** are particularly suitable for industrial processes for the following reasons:

(a) They have simple nutritional requirements.

(b) Growth conditions can be controlled very precisely in vessels in which the microorganisms are grown.

(c) They have fast growth rate.

(d) Reaction can be carried out at lower temperatures than conventional industrial procedures energy loss is therefore lower.

(e) They produce higher yields and have higher specificity than conventional processes.

(f) The genetics of microorganisms is relatively simple and techniques for genetic manipulations are continually advancing.

Many similar attempts involving genetic engineering are currently being made to protect plants against other pests such as fungi, bacteria and viruses. Genetically engineered pest resistance has three major advantages over other forms of pest control:

(a) Pesticides are expensive and time consuming to apply.
(b) Pesticides are rarely selective and kill harmless and useful organisms as well, such as pollinators.
(c) Some pesticides accumulate in the environment and cause long-term changes in plant and animals.

Adverse Effect of Inorganic Insecticides on the Environment

Inorganic insecticides introduce toxic lead and arsenate into the environment.

Synthetic pryrethroids and rotenones are toxic to fish. Natural pyrethrroids, rotenones and nicotines are not selective in their action, killing both pest and useful insects (Odiete, 1999). They are very toxic to vertebrates. In severe acute organophosporus poisoning, symptoms include cold sweat, salivation, nausea, bronchi constriction and tightness of chest, with decrease in blood pressure. Organophoshorus poisoning, results from their inactivation of the enzyme, acetylcholinesterase leading to accumulation of acetylcholine in automatic ganglia, central nervous system and neuromuscular functions. The terminal results is death arising from asphyxiation caused jointly by

(1) Broncho constriction (of lungs)
(2) Decrease in blood pressure
(3) Failure of the diaphragm and
(4) Depression of the respiratory centre in the brain (Odiete, 1999)

Persistence of Inorganic Insecticides in the Environment

DDT, its metabolite DDE and dieldrin have been reported to persist in the environment for months or years and non-biodegradable, (Robinson, et al, 1967 in Odiete 1999).

Appendix IA and B, show biomagnification of DDT and dieldrin. Birds that eat grains or fish are adversely affected by food chain effect or biomagnification.

Hunt and Bischoff (1960) observed that when Clear Lake in California in 1949 was sprayed with DDD to destroy mosquito larvae, it was applied at the rate of lpart in 70 millions, it became concentrated in plankton 5 parts in 1 million then in plankton eating and flesh eating fishes and finally to Grebes (diving birds) where concentration varied from 40 to 2500 parts per million and caused high mortality of the birds. Only 30% survived. This story is a clear eye-opener to the enormous damage the application of inorganic and synthetic botanical pesticides (insecticides) can do to the environment.

Conclusion and Recommendations

This paper has attempted to show that certain microorganisms or their protein extracts have the capacities to selectively kill insect pests of agricultural, ecological and health importance. It also highlights how genetic engineering of these microbes could boost their efficiency as agents of pest control.

0. It is recommended that in order to fully realize the objective of using microbial insecticides, which are more environmental friendly, in place of inorganic insecticides, more researches need to be conducted on genetic engineering of relevant microbes.
1. Towards this end, the newly formulated policy on Biotechnology by the Federal Government of Nigeria must entail the allocation of adequate funds for the conduct of intensive researches into genetic engineering of microbes important as agents in environmental clean-up such as in microbial pest control.
2. Governments, individual entrepreneurs and multinational companies should make concerted efforts to support, utilize and commercialize the results of Research and Development (R&D) in genetic engineering of microorganisms (GEOM).

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Appendix I, A And B

(A) Biomagnification of DDT and its Metabolites in the Environment <u>(After Kennaga, 1972)</u>

Environment	**Organism**	**Biomagnification**
Soil	Roots of crops	0.1
	Slugs	4
	Earthworms	73
	Algae	33
	Crabs	144
	Shrimps	2800
	Claims	7000
	Fish	829000

(B) Biomagnification of Fieldrin in Marine Organism off the Coast of Northumberland (Robinson et al., 1967).

Environment	**Organism**	**T rophic level**	**Concentration in ppm**
Water	Seaweed's: Fucus serratus laminaria digitata	1	0.001
	Primary consumer Echinus esculentis mytilus edulis	2	0.027
	Secondary consumer Herrings: Clupea barengus	3	0.023 0.057
	Tertiary consumer Fish-eating bird	4	0.5