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Bio Pesticides: An Eco-Friendly Approach for Integrated Pest Management - A review

Banothu Dasmabai[1], Lunavat Gopala[2] and Raju Kumar Lingala[3]

[1,3] Assistant Professor, Department of Veterinary Parasitology, CVSc, Rajendranagar, PVNRTVU, Hyderabad, Telangana-500030

[2] Assistant Professor, Department of Veterinary Microbiology, CVSc, Korutla, Jagtial District, PVNRTVU, Telangana-505326.

Corresponding Author: dasmabai@gmail.com

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INTRODUCTION

Insect pests of Veterinary importance, such as flies (biting, non-biting), fleas, lice (biting, sucking), ticks (soft, hard) and mites (burrowing, non-burrowing, follicular) cause harmful effects such as,

Direct effects:

- Annoyance, worries and nuisance through painful bite,
- Blood and tissue fluid loss,
- Skin inflammation and pruritis,
- Toxic and allergic reaction
- Secondary bacterial infection of wounds caused by the larvae of *Gastrophilus* in horse, *Oestrus ovis* in sheep, blow fly myiasis, may lead to septicaemia and death.

Indirect effects:

- Decreased feed conversion efficiency,
- Reduced milk, meat, wool and egg production,
- Weight loss,
- Act as vectors for many bacterial, viral, protozoan and rickettsial diseases.

Important diseases transmitted by insect as vectors

Insects	Important diseases
***Culicoides* spp.**	Bluetongue, African horse sickness &Epizootic haemorrhagic disease
Musca domestica	Bacterial diseases-cholera, typhoid, paratyphoid, tuberculosis, salmonella dysentery, and leptospirosis,Viral diseases-poliomyelitis and infectious hepatitis and Protozoan diseases - amoebic dysentery and giardiosis.

Mosquito spp.	Dengue, Chikungunya, malaria, dog heart worm, yellow fever
***Simulium* spp.**	Eastern equine encephalitis, vesicular stomatitis, *onchocerci gibsoni*
Phlebotomine sandflies	Visceral and cutaneous leishmanioses.

Use of insecticides to reduce or eliminate insect pests is therefore often required to maintain health and to prevent economic loss in food animals. The introduction of synthetic insecticides, like Organochlorines in 1940s, organophosphates in the 1960s, carbamates in 1970s, pyrethroids in 1980s and later neonicotinoids, dominated many natural control methods, such as using of botanicals, predators, and parasitoids. After twenty years of organochlorines introduction, came to know that synthetic insecticides induce widespread environmental contamination, toxicity to non-target organisms, development of resistance against insecticides, and negative effects on animal and human health (Pretty, 2009).

Hence, alternative means of controlling harmful insects have been gaining popularity in the current climate of environmental awareness and public concern. The word bio insecticides came to era of present world to control insect pests.

A. Biorational insecticides- Referring to insecticides that have limited or no adverse effects on the environment, non- target organisms including humans.

B. Biochemical insecticides- botanicals, insect growth regulators, insect pheromones, photoinsecticides, and inorganics

C. Biological insecticides- parasitoids, predators, nematodes, and pathogens (virus, bacteria, fungi, or protozoa)

D. Transgenic insecticides- Genetically modified plants or organisms.

In developing countries, bio pesticides offer unique and challenging opportunities for exploration and development of their own bio insecticides. Nanotechnology has become one of the most promising new technologies in the recent decade for protection against insect pests. The interest in bio insecticides is based on the advantages associated with such products such as:

- Inherently less harmful and less environmental load
- Designed to affect only one specific pest or, in some cases, a few target organisms
- Often effective in very small quantities and often decompose quickly, thereby resulting in lower exposures and largely avoiding the pollution problems and
- When used as a component of Integrated Pest Management (IPM) programs, bio pesticides contribute greatly.

Biochemical Control:

Botanical insecticides

Plants produce toxic substances as natural defences against pests, such as insects and pathogens. These substances can be extracted from plants and used in the production of commercial insecticides. The use of plants, plant material (bark, leaves, roots, seeds, and stem) or crude plant extracts as sources of insecticidal substances. Traditionally used botanical insecticide products include nicotine, rotenone and pyrethrum.

Essential oils (EO) are complex mixtures of volatile organic compounds produced as secondary metabolites in plants; they are constituted by hydrocarbons (terpenes and sesquiterpenes) and oxygenated compounds (alcohols, esters, ethers, aldehydes, ketones, lactones, phenols and phenol ethers). Some monoterpenes such as a-pinene, cineole, eugenol, limonene terpinolene, citronellol, citronellal, camphor and thymol are common constituents of EO. Their composition may vary considerably between aromatic plant species and varieties, and within the same variety from different geographic areas.

Among EO-producing plants, some genus such as *Cymbopogon spp. Eucalyptus spp.* and *Ocimum spp*. have been widely studied. The rapid action against some pests is indicative of a neurotoxic mode of action, and there is evidence for interference with the neuromodulator octopamine (Enan, 2005) or GABA-gated chloride channels (Priestley *et al*., 2003).

Azadirachta indica- neem tree

Azadirachta indica, also known as neem, nimtree, ineem and Indian lilac is a tree in the mahogany family Meliaceae. It is a native to India and the Indian subcontinent including Nepal, Pakistan, Bangladesh and Srilanka.

Active ingredient: Azadirachtin

Mode of action : Antifeedency, Insect growth regulator, Oviposition deterrence &fecundity reduction, Repellent activity

Curcuma longa- Turmeric:

It is a perennial plant with roots or tubers oblong- palmate, and deep orange inside. In fresh state, the roots have an aromatic and spicy fragrance, which by drying gives way to a more medicinal aroma. The origin of turmeric is from South East Asia or South Asia.

Active compound & action

The yellow-orange color of turmeric comes from yellow pigment found in the rhizomes called **curcumin**. It has well-known insecticidal and repellent effects on insect pests. The concentration of another important component ***ar*-turmerone** harvested from rhizomes was 0.32% (dwt).

Allium sativum-Garlic

It is a bulbous plant. It grows up to 1.2 m (4 ft) in height. It occur in China, India, South korea, Egypt, Russia etc. The garlic plant's bulb is the most commonly used part of the plant. Active compound- **allicin** (2-propene-1-sulfinothioic acid S-2-propenyl ester. Activity has been reported against a number of dipteran, coleopteran, lepidopteran and hemipteran pests.

Eucalyptus spp. (Gum tree)

It is a diverse genus of flowering trees and shrubs in the myrtle family, Myrtaceae. *Eucalyptus* is one of three similar genera that are commonly referred to as "eucalypts", the others being *Corymbia* and *Angophora*. Members of the genus dominate the tree flora of Australia, and include *Eucalyptus regnans*, the tallest known flowering plant on Earth.

Cymbopogon citrates (Lemongrass)

The essential oil of *Cymbopogon citratus*, known as “lemongrass”, is commonly used by folk medicine in many countries. Native from India and Southeast Asia, it is distributed in numerous tropical countries, including Brazil. Active ingredient are **citral and 1.8 cineole** and they have important repellent and insecticide activity. The citral constitute total of 97.92% from Brazil (Pinto *et al*.,2015).

Pyrethrin- Oldest and safest insecticides

The ground, dried flowers of *Chrysanthimum cinerariaefolium* (Asteraceae) were used in the early 19th century to control body lice during the napoleonic wars. Pyrethrum contains three esters of chrysanthemic acid and three esters of pyrethric acid. Among the six esters, those incorporating the alcohol pyrethrolone, namely **pyrethrins I and II**, are the most abundant and account for most of the insecticidal activity. Technical grade pyrethrum, the resin used in formulating commercial insecticides, typically contains from 20% to 25% pyrethrins.

Mechanism of Action of Pyrethrin

Pyrethrin effect the insect on contact, creating disturbances in the nervous system which eventually result in convulsions and death. Pyrethrin acts on insects with phenomenal speed causing immediate paralysis, notably in flying insects, some of which are immobilized within 1 sec. It blocks voltage-gated sodium channels in nerve axons.

Insect growth regulators

Insect growth regulators (IGRs) are chemical compounds that alter growth and development in insects. They don’t directly kill insects, but interfere with the normal mechanisms of development, resulting in insects dying before they reach adulthood. IGRs are classified into two general categories based on mode of action:

1. Substances interfering with the action of insect hormones and
2. Chitin synthesis inhibitors.

1. Substances interfering with the action of insect hormones

Growth and development of insects are regulated by hormones, such as

1. **Prothoracicotropic hormone** controls the secretion of the molting hormone (ecdysone) from the prothoracic gland.
2. **Ecdysone** is responsible for cellular programming
3. **Juveline hormone (JH)** is one of the most pleiotropic hormones known and functions in various aspects such as embryogenesis, molting and metamorphosis, reproduction, diapause, communication, migration/ dispersal, caste differentiation, pigmentation, silk production, and phase transformation. The major function of JH is the maintenance of larval status or the so- called juvenilizing effect.

Juvenile hormone analogues (JHAs)

In 1967 Carrol Williams proposed that the term ‘‘third generation pesticide’’ be applied to the potential use of the insect juvenile hormone (JH) as an insecticide. Methoprene, the first compound introduced into the market. Many naturally occurring JHAs, also called juvenoids, have been isolated from plants such as the ‘‘paper factor’’ from the balsam fir tree (*Abies balsamea*), and juvocimenes from the sweet basil plant (*Ocimum basilicum*). During coevolution, the plants probably developed these JHAs to defend themselves against insects.

Action

Treatment of the larva in its last instar with JHA severely interferes with normal metamorphosis and results in various larval–pupal intermediates that do not survive. JHAs block embryonic development at blastokinesis and act as ovicides. JHAs induce sterility in both sexes of adult tsetse flies (Langley et al., 1990).

Chitin synthesis inhibitors:

Over the past three decades, the chitin biosynthetic pathway has proven to be important for developing insect control agents that selectively inhibit any of the chitin synthetic steps in insects. Chitin synthesis inhibitors act on the larval stages by inhibiting or blocking the synthesis of chitin which represent 30-60% of the insect exoskeleton structure. Two types of insect regulatory chitin synthesis inhibitors (CSI) have been developed and used as commercial compounds for controlling insect pests: The Benzylphenyl ureas (BPUs), and Triazine/pyrimidine derivatives.

1. Benzoylphenyl ureas:

It was in the early seventies that the first chitin synthesis inhibitor, a benzylphenylurea, was discovered by scientists at Philips-Duphar BV, (now Crompton Corp., Weesp, The

Netherlands), and marketed as Dimilin by the Uniroyal Chemical Company (Crompton Corp. Middlebury, CT) in the USA. Studies with diflubenzuron, the most thoroughly investigated compound.

Action:

On developing larvae its ruptures, the malformed cuticle act as ovicides, reducing the egg laying rate or hindering the hatching process by inhibiting embryonic development or failure of hatchability**.** It alters cuticle composition, especially inhibition of chitin, resulting in abnormal endocuticular deposition that affects cuticular elasticity and firmness, and causes abortive molting Inhibit the transport of UDP-GlcNAc across biomembranes Block the binding of chitin to cuticular proteins resulting in inhibition of cuticle deposition and fibrillogenesis

Inhibit the formation of chitin due to an inhibition of the protease that activates chitin synthase, and activation of chitinases and phenoloxidases, which are both connected with chitin catabolism

Affect ecdysone metabolism, resulting in ecdysone accumulation that stimulates chitinase, which in turn digests nascent chitin. Blocks the conversion of glucose to fructose- 6-phosphate and Inhibit the DNA synthesis (Oberlander and Smagghe, 2001).

Triazine/pyrimidine derivatives

Cyromazine

Cyromazine (Larvadex ®, Trigard®), is an IGR with contact action interfering with molting and pupation. Cyromazine may inhibit growth or expansion of the body wall (or both) sufficiently to prevent normal internal growth, producing the observed symptoms and leading to abnormal development.

It fed to poultry or sprayed to control flies on animals, in manure of broiler and egg producing operations. It controls blowfly infesting sheep and persist for up to 13 weeks (O'Brien & Fahey, 1991) after a single pour-on application, or longer if applied by dip or shower.

Dicyclanil

Dicyclanil (ZR ®, ComWin ®), a pyrimidine derivative, is highly active against dipteran larvae and available as a pour-on formulation for blowfly control in sheep in Australia and New Zealand providing up to 20 weeks' protection.

Safety

CSIs consider as soft insecticides

Low mammalian toxicity

Ease of their synthesization

their pest selectivity

No accumulation in soil and water

Typically “safer” to use around humans, pets, and natural enemies and

Effective when applied in very minute quantities.

Drawback

Sensitive to UV light

Some insects acquired resistance against some IGR

Semio-chemicals:

Semio chemical is a Greek word, semeion which means signal it is a term used for chemical substance or a mixture of chemicals that is used for communication it is a behaviour and physiology modifying chemical and all arthropods use semiochemicals which are naturally released for communication and to alter behaviour of other individuals these are secreted external to the body and when recognized will result in a specific behaviour response such as food finding, mate finding,escape and other such behaviors.

Animals communicate with each other by means of physical and chemical stimuli information-bearing compounds, or semiochemicals, cause other individuals to modify their behaviour. They occur in vertebrates as well as invertebrates and are probably characteristic of all animals

Semiochemicals subdivided into allelochemicals and pheromones these allelochemicals further subdivided into

1. Allomones
2. Kairomones
3. Synamones
4. Antimones

Pheromones: These are best known**,** intensively studied group of Semio-chemicals pheromones can be classified as follows

1. Arrestment / Assembly pheromones
2. Attraction Aggregation Attachment pheromone (AAAP)
3. Sex pheromones each of which mediates different aspects of courtship process

a. Attachment sex pheromones

b. Mounting sex pheromones

c. Genital sex pheromones

4. Oviposition pheromones

Biological control

In biological control natural enemies have been utilized in the management of insect pests for centuries. However, this last 100 years has seen a dramatic increase in their use as well as our understanding of how they can better be manipulated as part of effective, safe, pest management systems.

Biological control includes four categories:

1. Microbes or pathogens (such as viruses, bacteria, protozoa, nematodes and fungi);
2. Predators (such as lady beetles and lacewings); and
3. Parasitoids (wasps and some flies).
4. Bio chemicals

Microbial insecticides

Bacteria

***Bacillus thuringiensis* (Bt)**: It is a widely occurring gram-positive, spore-forming soil bacterium that produces parasporal, proteinaceous, crystal inclusion bodies during sporulation. *Bt* is a member of the *Bacillus cereus* group. Bt is occur in soil, leaf litter, leaf surfaces, insect feces, and as a part of the flora in the midguts of many insect species.

There are several insecticides based on various sub-species of *Bacillus thuringiensis* Berliner (*Bt*), such as

B thuringiensis israelensis (Bti), with activity against mosquito larvae, black fly (simuliid), fungus gnats, and related dipterans species

B thuringiensis kurstaki (Btk) and *B thuringiensis aizawai* (Bta) with activity against lepidopteran larval species

B thuringiensis tenebrionis (Btt), with activity against coleopteran adults and larvae; and

B thuringiensis japonensis (Btj) strain *buibui*, with activity against soil-inhabiting beetles.

Bacillus sphaericus: Its control mosquito larvae, particularly *Culex* and *anopheline spp.*, especially those breeding in polluted water. It controls also black fly, *Simulium* sp., the vector of river blindness disease. Registered *B. sphaericus* product is **Vectolex CG** (Valent BioSciences).

Mode of action

The insecticidal properties of Bt are largely a function of the presence of extra-chromosomal plasmids in the cell. The major determinants of BT insecticidal properties are the delta-endotoxins. These end toxins form two multigenic families, cry and cyt. **Cry proteins** is a parasporal inclusion protein from *B. thuringiensis* that exhibits toxic effect to a target organism, or any protein that has obvious sequence similarity. More than 200 different cry genes have been isolated.

Upon ingestion by an insect, the crystal proteins (cry) are solubilised and the insect gut proteases convert the original protoxin into smaller toxins. These hydrolysed toxins bind to the insect's midgut cells at high-affinity and specific receptor binding sites where they interfere with the potassium ion dependent, active amino acid symport mechanism decreasing absorption of minerals and nutrition from midgut and finally death of the columnar cells. This disruption causes the formation of large cation-selective pores that increase the water permeability of the cell membrane. A large uptake of water causes cell swelling and eventual rupture, disintegrating the midgut lining. The toxin stops feeding, this action hinder further damage caused by the feeding larva, and do not directly kill insects, but young larvae may starve to death and may die from bacterial infection over a longer period.

Virus

Insect viruses have traditionally been associated with biocontrol of insect pests, and since the 1980s. Entomopathogenic viruses are obligate disease-causing organisms that can only reproduce within a host insect. There are presently more than 20 known groups of insect pathogenic viruses, which are classified into 12 viral families.

MdSGHV virus

Salivary gland hypertrophy virus of house flies (MdSGHV) is one of three members of the hytrosaviridae, a recently described family that includes pathogens of adult house flies, tsetse flies (*Glossina* spp.), and the narcissus bulb fly (*Merodon equestris* Fabr.) (Lietze *et al*., 2011). The virus an enveloped, double stranded, circular DNA virus with a 124,279 bp genome. MdSGHV was first discovered infecting flies at a dairy farm in central Florida in the early 1990's.

The most conspicuous feature of infection is the presence of greatly enlarged (hypertrophied) salivary glands with a blue-whitish appearance that often dominate the abdominal cavity of the fly when dissected. Both sexes can be infected, with somewhat higher prevalence rates in males. Viral replication and morphogenesis is restricted to salivary gland cells, although complete virions are also found in asymptomatic tissues such as midgut, ovaries, fat body and brain. Infected flies of both sexes have reduced mating success and shorter life spans than healthy flies.

Infected females deposit ca. one million virus particles each over a period of seconds when they feed on solid foods (Lietze *et al*., 2009). Healthy flies can become infected when they are given food or water from cages of infected flies, and even when they are housed in cages from infected flies and given clean food and water supplies. Viable virus particles pass through the alimentary tract of infected flies and are deposited with feces, albeit at low rates (Lietze *et al*., 2009). Further research with new formulations to improve stability, shelf life and adherence to target flies could greatly improve prospects for use of MdSGHV as an operational biopesticide. Deltabaculovirus (dipteran-specific NPVs) (Jehle et al., 2006).

Mechanism of action of Virus

Insect feeding on virus - contaminated foliage

Close up of occlusion bodies (OBs)

Lumen of digestive tract alkaline in condition

Virus particles being released from OBs and attaching to brush border of gut cells

Replication Of virus in insect cell

Virus-Iridescent, cytoplasmic poly hidrosis

Entomopathogenic fungus:

Hyphomycetes

Beauveria bassiana (Bals.) and Metarhizium anisopliae (*Met*.) are two species of entomopathogenic fungi, belonging to the hyphomycetes group, that are natural inhabitants of soil, where they are found infecting a wide range of insect species that spend at least one stage of their life cycle in the soil. They are ubiquitous worldwide and comprise a large number of different strains/isolates which differ in their geographical origin or host specificity. The main infection route is through the integument, although they can also be ingested and enter the organism through the digestive tract, or through the trachea, or wounds. The most common method used has been the immersion of any insect stage (larva, pupa or adult) in a conidia solution, although topic, oral or contact applications have also been tested.

Mode of action

These hyphomycetes can infect and kill insects without being ingested. The spores of the fungi, called **conidia**, attach to the insect's external tegument in a passive and non-specific way and subsequently germinate and penetrate the cuticle. Once in the hemocoel, the mycelium grows throughout the host, forming hyphal bodies called blastospores. The fungi produce **destruxins** causing paralysis and insects die between 3-14 days after infection, depending on species, size and fungal isolate. Under suitable conditions hyphae can emerge from the cadaver and produce conidia on the exterior of the host which can be dispersed by wind or water.

Nematodes

Nematodes from the families steinernematidae and heterorhabditidae have proven to be the most effective as biological control organisms to control a wide range of insect pests including filth flies, cat flea.

Action

The life cycle of most nematodes includes an egg stage, four juvenile stages, and an adult stage. The third juvenile stage, dauer, is the only infective and free living stage which is capable of surviving in the soil; its function is to locate, attack, and infect an insect host through its breathing holes, mouth, or anus, but some species are capable of penetrating thin areas of the insect's cuticle. After that, the nematodes release special bacteria into the insect. The toxins produced by the bacteria kill the insect after a few days. The bacteria multiply inside the body of the insect and the nematodes eat the bacteria. The nematodes mature, mate, and multiply inside the insect. Eventually, the insect's body becomes filled with nematodes. Infective stage nematodes then exit the insect body searching of other insects to infect.

The nematode bacterium relationship is highly specific: only *Xenorhabdus* spp. bacteria co-exist with steinermatids, and only *Photorhabdus* bacteria co-exist with heterorhabditids. Under optimal conditions, it takes 3–7 days for steinernemadtids and heterorhabditids to complete one life cycle inside a host from egg to egg. Emergence of infective juveniles from the host requires about 6–11days for steinernemadtids and 12–14 days for heterorhabditids. The ability of any biological control nematode to infect a particular insect can be affected by nematode and insect behavior, physical barriers, and immune responses. Over 30 species of beneficial nematodes have been identified. Seven species have been commercialized worldwide such as *Steinernema carpocapsae, S. feltiae, S. glaseri, S. riobravis, Heterorhabditis bacteriophora, H. megidis,* and *H. marelatus.*

Paraiotonchium muscadomesticae infect housefly larvae and descendants of the nematodes invade and damage the ovaries of adult female flies and are deposited in the larval habitat when the flies attempt to oviposit. Infected adults lived about half as long as uninfected flies. Nematodes were effective in the laboratory but persisted in manure only for 3-7 days.

Predators

“Free- living animal that feeds on other animals (prey); it may attack prey in both its immature and adult stages; usually more than one prey individual is required for the predator to complete its life cycle.” Major types of insects that are predaceous: **dragon flies, damselflies, mantids, true bugs, some thrips, lacewings & relatives, beetles, some wasps, ants & some flies.** Histerid beetles and macrochelid mites feed ravenously on fly eggs and young larvae and have been studied extensively.

Carcinops pumilio (Erichson) (Coleoptera: Histeridae), commonly found in poultry manure, is an important predator of house fly eggs and larvae. The use of this species is considered to be compatible with that of pteromalids such as *Spalangia endius* Walker, because *C. pumilio* feeds on fly eggs and larvae and not on the host pupae, which the parasitoids require. Predacious fishes such as *Poecilia rectculata & Gambusia affins* (guppy fishes) as a larvivorous for control of mosquitoes and for culicoides

Parasitoids

An arthropod that parasitizes and kills another arthropod (insects, mites, spiders and other close relatives) host; a parasitoid is parasitic in its immature stages and free living as an adult. The major types of insects that are parasitoids wasps, flies, some beetles, and mantis and twisted winged parasites.

Action: Adult female parasitoids lay their eggs inside the host by penetrating the body wall with their ovipositor or they attach their eggs to the outside of the host’s body.

Transgenic pesticides

Genetically modified organisms

Transgenic organisms are genetically altered by artificial introduction of DNA from another organism and the artificial gene sequence is referred to as a transgene. The development of recombinant DNA techniques improves the efficacy of Bti through combining the most potent insecticidal proteins from Bti, Btj, and Bs into new bacterial strains that are ten-fold more toxic than wild type species of Bti and Bs used in current commercial formulations.

Safety

They are much more environmentally compatible than most chemical insecticides.

Costs are similar to that of new chemical insecticides.

Therefore, recombinant bacterial larvicides will play an important role in controlling pests and vectors in the near future Federici et al (2010).

Transgenic insects/ genetic control of insect pests

A genetically modified (GM) insect is an insect that has been genetically modified, either through mutagenesis, or more precise processes of transgenesis, or cisgenesis.

Motivations for using GM insects include biological research purposes and genetic pest management. Genetic pest management capitalizes on recent advances in biotechnology and the growing repertoire of sequenced genomes in order to control pest populations, including insects. Insect genomes can be found in genetic databases such as NCBI, and databases more specific to insects such as FlyBase, VectorBase, and Beetle Base.

Types of genetic pest management

The sterile insect technique (SIT) was developed conceptually in the 1930s and 1940s and first used in the environment in the 1950s. SIT is a control strategy where male insects are sterilized, usually by irradiation, then released to mate with wild females. If enough males are released, the females will mate with mostly sterile males and lay non-viable eggs. This causes the population of insects to crash, and in some cases can lead to local eradication. Irradiation is a form of mutagenesis which causes random mutations in DNA.

Release of Insects carrying Dominant Lethals (RIDL) is a control strategy using genetically engineered insects that have (carry) a lethal gene in their genome (an organism's DNA). RIDL genes only kill young insects, usually larvae or pupae. This lethal gene has a molecular on and off switch, allowing these RIDL insects to be reared. The lethal gene is turned off when the RIDL insects are mass reared in an insectory, and turned on when they are released into the environment. RIDL males and females are released to mate with wild males and their offspring die when they reach the larval or pupal stage because of the lethal gene.

It also called as Oxitec's technology. The first open field trial by Oxitec was carried out in 2010 in the Caribbean Island of Grahnd Cayman. The trial was successful in reducing the mosquito population by 80%. Similar trials have since been carried out in west Panama, Malaysia and more recently in Brazil with at least 90% reduction in vector population.

Drawbacks

Face contrasting expectations of multiple stakeholders, the management of which will prove critical to safeguard support and avoid antagonism, so that potential public health benefits can be fully evaluated.

Nanoparticles- future trends as bio insecticides in control of insect pests

The potential uses and benefits of nanotechnology are enormous. These include enhancement involving nanocapsules for vector and pest management and nanosensors for pest detection. Nanoparticles are 1-100 nm in diameter. Nanotechnology deals with the targeted nanoparticles which exhibit different physical strength, chemical reactivity, electrical conductance, and magnetic properties. Nanoparticles help to produce new pesticides, insecticides and insect repellants .

Nanoencapsulation is a process through which a chemical or bio insecticides are slowly but efficiently released to a particular host for insect pest control. Release mechanisms include diffusion, dissolution, biodegradation and osmotic pressure with specific pH.

Velayutham k *et al*., 2013 studied, the larvicidal aqueous crude bark extracts and synthesized Ag NPs of *Ficus racemosa* against the larvae of *Cx. quinquefasciatus* and *Cx.gelidus*. however, the highest mortality was found in synthesized Ag NPs of *F. racemosa* at the concentration of 25 mg/L.

Conclusion

Over the past 20 years, biorational insecticides are gaining importance in control of insect pests and vectors, which affect the livestock animals and humans. Now days, essential oils such as neem, citriodora, eucalyptus, lemon grass, sweat basil, cumin and clove oil are coming slowly into the market by various company, but because of sensitive to UV light, protective effects usually dissipate relatively quickly and most studies are invitro, which makes them less effective. To with stand this drawback, combining active oils of more plants and adding UV protectants. Further research on blends of essential oils and improved formulations and delivery systems could lead to substantial improvements in the performance. Insect growth regulators like methoprene, pyriproxifen & lufenuron are using along with chemical insecticides. Different lure designs releasing synthetic pheromones which are specific such as Z-9-tricosene for attract house flies, carpoic acid – oviposition pheromone attract mosquitoes and methylgermacrene B attract sand flies are studied. For improvement of pheromones, understanding the mechanisms of communication systems of insects, behaviour and mating systems among target insects and non-target organisms is important.

Inspite of safe to environment and non- target organisms, microbial bioinsecticides like *B. thuringiensis, B. bassiana and M. anisopliae* are limited in market due to less field studies, sensitive to local environment in farms, UV radiations, heat and need proper applications. The utilization of microbial insecticides in integrated pest management model requires high scientific study such as systematic surveys on properties, mode of action, pathogenicity, etc. Ecological studies are necessary on the dynamics of diseases in insect populations because the environmental factors play a vital role in disease outbreaks to control the pests. In order to improve mass production technologies contamination should be reduced with the improvement of formulation potency and increase in shelf-life of microbial bioinsecticides. Genetic and recombinant biotechnological tools would lead to the production of strains with improved pathogenesis and virulence. All aspects study should be done especially; persistence, resistance, dispersal potential, the range of non-target organisms affected directly and/or indirectly in order to solve the problem of regarding the regulatory and registration.

Sterile insect technique and oxitecs technologies should be adopted to other insects to control. Nanoencapsulation delivery system must be encouraged. Remarkable gap between different research institute and such company engaged in commercialization must be avoided

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