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Review Article

Biopestcides: Types and Applications

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ABSTRACT
Food losses in the world are high. The main aspect of this problem is the due to damage of crops that leads to loss of production and this also affects the health of humans.Though,pestcides are developed to control this but they have created serious ecological problems. Biopesticides are very effective in the agricultural pest control without causing serious harm to ecological chain or worsening environmental pollution.Thia paper presents the need of biopestides ,its different types and it applications.

Keywords: Biopesticides ,Integreated Pest Management , Microbial Biopestcides.

INTRODUCTION

In recent years, few environmental issues have aroused the concern of the public as much as pesticides, especially in relation to the health of children. In spite of the many published studies on the subject of pesticides and human health, there remains deep controversy surrounding this crops.They are in a dilemma to either sacrifice a significant share of their crops to pests or use highly toxic pesticides that can harm human health and the environment.Biopesticides are key elements of incorporated insect management (IPM) programs, and are receiving much practical attention as a means to reduce the fill of artificial chemicals being used. Heavy use of synthetic chemicals for pest control started from 1940s. Till then we were using natural insecticides namely rotenone from the roots of derris plant, and pyrethrum from the flower heads of a species of chrysanthemum.After twenty years it was found that the level of synthetic pesticides were building and were not biodegradable and their harmful effects started coming out. there is a need to create biopesticides which are effective, eco-friendly and do not leave any harmful effect on environment. Gardening is the back-bone of Native Indian economic climate. Up to 70% of the inhabitants is involved in town industry straight or in a roundabout way. Growing Native Indian inhabitants needs sufficient town produce. Gardening and the agriculture vegetation are vulnerable to problems by various kinds of unwanted pest infestations in form of bugs, infection, harmful bacteria or virus or fresh mushrooms and control of these has become necessary to reduce failures to a minimum.

'Biopesticides' are certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals. These include for example; fungi such as Beauveria sp., bacteria such as Bacillus sp., neem extract and pheromones. Similarly Canola oil and baking soda have pesticide applications and are considered as biopesticides. The use of these materials is widespread with applications to goliage, turf, soil, or other environments of the target insect pests. In a much simpler way we can say that these are pest management tools that are based on beneficial microorganisms (bacteria,viruses, fungi and protozoa), beneficial nematodes or other safe, biologically based active ingredients. Benefits of biopesticides include effective control of insects, plant diseases and weeds, as well as human and environmental safety. Biopesticides also play an important role in providing pest management tools in areas where pesticide resistance, niche markets and environmental concerns limit the use of chemical pesticide products. The most widely known microbial pesticides are varieties of the bacterium *Bacillus thuringiensis*, or Bt, which can control certain insects in cabbage, potato, and other crops. Bt produces a protein that is harmful to specific insect pest. Certain other microbial pesticides act by out-competing pest organisms. Microbial pesticides need to be continuously monitored to ensure that they do not become capable of harming non-target organisms, including humans.

Some success stories about successful utilization of biopesticides and bio-control agents in Indian agriculture include[1]

1. Control of diamondback moths by *Bacillus thuringiensis,*
2. Control of mango hoppers and mealy bugs and coffee pod borer by *Beauveria,*
3. Control of *Helicoverpa* on cotton, pigeon-pea, and tomato by *Bacillus thuringiensis,*
4. Control of white fly on cotton by neem products,
5. Control of *Helicoverpa* on gram by N.P.V.,
6. Control of sugarcane borers by *Trichogramma* and
7. Control of rots and wilts in various crops by *Trichoderma*-based products.

Table 1: Biopesticides Registered under Insecticides Act,1968[2]

S.No.	Name of the Biopesticides
1	*Bacillus thuringiensis var. israelensis*
2	*Bacillus thuringiensis var. kurstaki*
3	*Bacillus thuringiensis var. galleriae*
4	*Bacillus sphaericus*
5	*Bacillus sphaericus*
6	*Bacillus sphaericus*
7	*Pseudomonas fluoresens*
8	*Beauveria bassiana*
9	NPV of *Helicoverpa armigera*
10	NPV of *Spodoptera litura*
11	*Neem based pesticides*
12	Cymbopogan

Types of Biopesticides

Biopesticides fall into three major categories[1]

A. Microbial pesticides

Microbial biopesticides represent an important option for the management of plant diseases. The United States Environmental Protection Agency (EPA) defines biopesticides as, "*certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals."* Microbial pesticides contain a microorganism (bacterium, fungus, virus, protozoan or alga) as the active ingredient. Microbial pesticides 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. They suppress pest by producing a toxin specific to the pest,causing a disease., Preventing establishment of other microorganisms through competition or Other modes of action.

The most widely known microbial pesticides are varieties of the bacterium *Bacillus thuringiensis*, or Bt, which can control certain insects in cabbage, potato, and other crops. Bt produces a protein that is harmful to specific insect pest. Certain other microbial pesticides act by out-competing pest organisms. Microbial pesticides need to be continuously monitored to ensure that they do not become capable of harming non-target organisms, including humans. organisms. Bt can be applied to plant foliage or incorporated into the genetic material of crops and as discovered, it is toxic to the caterpillars (larvae) of moths and butterflies. These also can be used in controlling mosquitoes and black flies. Several strains of Bt have been developed and now strains are available that control fly 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.

B. Plant- Incorporated-Protectants(PIPs)

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 the gene into the plants own genetic material. Then the plant, instead of the *Bt* bacterium manufactures the substance that destroys the pest. Both the protein and its genetic material are regulated by EPA; the plant itself is not regulated.

C. Biochemical pesticides

These are naturally occurring substances such as plant extracts, fatty acids or pheromones that control pests by non-toxic mechanisms. Conventional pesticides, by contrast, are synthetic materials that usually kill or inactivate the pest. Biochemical pesticides include substances that interfere with growth or mating, such as plant growth regulators, or substances that repel or attract pests, such as pheromones. Because it is sometimes difficult to determine whether a natural pesticide controls the pest by a non-toxic mode of action, EPA has established a committee to determine whether a pesticide meets the criteria for a biochemical pesticide. 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. Man-made pheromones are used to disrupt insect mating by creating confusion during the search for mates, or can be used to attract male insects to traps. Pheromones are often used to detect or monitor insect populations, or in some cases, to control them.

Advantages of Using Biopesticides

Biopesticides are usually inherently less toxic than conventional pesticides.Biopesticides generally affect only the target pest and closely related organisms, in contrast to broad spectrum, conventional pesticides that may affect organisms as different as birds, insects, and mammals.They often are effective in very small quantities and often decompose quickly, thereby resulting in lower exposures and largely avoiding the pollution problems caused by conventional pesticides.When used as a component of Integrated Pest Management (IPM) programs, biopesticides can greatly decrease the use of conventional pesticides, while crop yields remain high.To use biopesticides effectively, however, users need to know a great deal about managing pests.

Uses of Biopesticides[3]

This review illustrates some selected examples of case studies on the effective utilization of bio-pesticides in pest management programme.

A. Microbial pesticides

1) Potential benefits of entomopathogenic fungi

Entomopathogenic fungi are important natural regulators of insect populations and have potential as mycoinsecticide agents against diverse insect pests in agriculture. These fungi infect their hosts by penetrating through the cuticle, gaining access to the hemolymph, producing toxins, and grow by utilizing nutrients present in the haemocoel to avoid insect immune responses[4]. Entomopathogenic fungi may be applied in the form of conidia or mycelium which sporulates after application. The use of fungal entomopathogens as alternative to insecticide or combined application of insecticide with fungal entomopathogens could be very useful for insecticide resistant management[5].

The commercial mycoinsecticide 'Boverin' based on *B. bassiana* with reduced doses of trichlorophon have been used to suppress the second-generation outbreaks of *Cydia pomonella* L.[6]. Anderson *et al*. (1989) detected higher insect mortality when *B. bassiana* and sublethal concentrations of insecticides were applied to control Colorado potato beetle (*Leptinotarsa decemlineata*), attributing higher rates of synergism between two agents.

A long term example of a classical biological control project using fungi is the program targeting the cassava green mite (CGM), *Mononychellus tanajoa* (Bondar) in Africa. It was in 1988, that exploration for potential natural enemies in Brazil revealed that the entomophthoralean *N. tanajoae* was one of the most important natural enemies of CGM in northeastern Brazil[7]. During the last 20 years, a series of studies was undertaken to make the release of this pathogen in Africa possible. The impact of the fungus *Neozygites floridana* on the tomato red spider mite, *Tetranychus evansi* Baker & Pritchard was demonstrated in the field and under screenhouses during four crop cycles of tomato and nightshade[8] in Piracicaba, SP, Brazil.

The effectiveness of seven strains of entomopathogenic fungi against *Ceratitis capitata* adults was evaluated in the laboratory[9]. Adults were susceptible to five of seven aqueous suspensions of conidia. The extract from *M. anisopliae* was the most toxic, resulting in about 90% mortality. The compatibility of the entomopathogenic fungus *Beauveria bassiana* (Balsamo) Vuillemin with neem was conducted against sweetpotato whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae), on egg plant[10]. The combination of *B. bassiana* and neem yielded the highest *B. tabaci* egg and nymph mortalities and the lowest LT50 value. Therefore, neem was used along with *B. bassiana* suspension as an integrated pest management program against *B. tabaci*.

The use of the insect-pathogenic fungus *Metarhizium anisopliae* against adult *Aedes aegypti* and *Aedes albopictus* mosquitoes has also been reported[11].The life span of fungus-contaminated mosquitoes of both species was significantly reduced compared to uninfected mosquitoes. The results indicated that both mosquito species are highly susceptible to infection with this entomopathogen.

Fungal biocontrol agents, including 10 isolates of *Beauveria bassiana*, *Metarhizium anisopliae*, and *Paecilomyces fumosoroseus* were bioassayed for their lethal effects on the eggs of the carmine spider mite, *Tetranychus cinnabarinus*[12].Results confirmed the ovicidal activity of the three fungal species and suggested the feasibility to search for more ovicidal isolates from fungal species that may serve as biocontrol agents against spider mites such as *T. cinnabarinus*. Two isolates of entomopathogenic fungi, *Beauveria bassiana* SG8702 and *Paecilomyces fumosoroseus* Pfr153, were also bioassayed against *T. cinnabarinus* eggs[13] Entomopathogenic fungi (Hypocreales) have been used for the control of potato psyllid, *Bactericera cockerelli* (Sulc) (Hemiptera: Triozidae) in an area endemic for zebra chip disease of potato[14]. Entomopathogenic fungi could provide a viable component for an integrated pest management strategy for control of *B. cockerelli* and other potato pest insects. Commercial formulations of *Metarhizium anisopliae* and *Isaria fumosorosea* and *abamectin* were conducted. It was observed that all fungal treatments significantly reduced plant damage and zebra chip symptoms. The biopesticide, afla-guard, delivers a nontoxigenic strain of Aspergillus flavus to the field where it competes with naturally occurring toxigenic strains of the fungus. In conjunction with the reductions in aflatoxin contamination, treatments produced significant reductions in the incidence of toxigenic isolates of A. flavus in corn[15]

2) Success of baculovirus pesticides

First well-documented introduction of baculovirus into the environment which resulted in effective suppression of a pest occurred accidentally before the World War II. Along with a parasitoid imported to Canada to suppress spruce sawfly *Diprion hercyniae*, an NPV specific for spruce sawfly was introduced and since then no control measures have been required against this hymenopteran species. In the past, the application of baculoviruses for the protection of agricultural annual crops, fruit orchards and forests has not matched their potential. The number of registered pesticides based on baculovirus, though slowly, increases steadily. At present, it exceeds fifty formulations, some of them being the same baculovirus preparations distributed under different trade names in different countries.

NPVs and GVs are used as pesticides but the group based on nucleopolyhedrosis viruses is much larger. The first viral insecticide Elcar™ was introduced by Sandoz Inc. in 1975[16]. Elcar™ was a preparation of *Heliothis zea* NPV which is relatively broad range baculovirus and infects many species belonging to genera *Helicoverpa* and *Heliothis.* HzSNPV provided control of not only cotton bollworm, but also of pests belonging to these genera attacking soybean, sorghum, maize, tomato and beans. In 1982 Sandoz decided to discontinue the production. The resistance to many chemical insecticides including pyrethroids revived the interest in HzSNPV and the same virus was registered under the name GemStar™. HzSNPV is a product of choice for biocontrol of *Helicoverpa armigera*[17]. Countries with large areas of such crops like cotton, pigeonpea, tomato, pepper and maize, e.g. India and China, introduced special programs for the reduction of this pest by biological means. In Central India, *H.armigera* in the past was usually removed by shaking pigeonpea plants until caterpillars fell from the plants onto cotton sheets. This technique is now used to obtain caterpillars which are fed on virus-infected seeds. Baculovirus preparations obtained in this way are used by farmers to prepare a bioinsecticide spray applied on pigeonpea fields. Another baculovirus, HaSNPV is almost identical to HzSNPV. It was registered in China as a pesticide in 1993[18]. It has been used for large scale biopesticide production and has been extensively used on cotton fields. Broad spectrum of biopesticide based on HaNPV is also used in India[19].

Caterpillars of moths belonging to *Spodoptera* genus are of primary concern for agricultural industry in many countries of the world. Two commercial preparations based on *Spodoptera* NPV are available in the USA and Europe. These are SPOD-X™ containing *Spodoptera exigua* NPV to control insects on vegetable crops and Spodopterin™ containing *Spodoptera littolaris* NPV which is used to protect cotton, corn and tomatoes. About 20 000 hectares of maize annually are controlled with *Spodoptera frugiperda* NPV in Brazil[20]. Many other species belonging to the Noctuidae family are economically important pests of sugarcane, legume, rice and others. *Autographa californica* and *Anagrapha falcifera* NPVs were registered in the USA and were field-tested at a limited scale. These two NPVs have relatively broad host spectrum and potentially can be used on a variety of crops infested with pests belonging to a number of genera, including *Spodoptera* and *Helicoverpa*.

The well-known success of employing baculovirus as a biopesticide is the case of *Anticarsia gemmatalis* nucleopolyhedrovirus (AgMNPV) used to control the velvetbeen caterpillar in soybean[20]. This program was implemented in Brazil in the early eighties, and came up to over 2,000,000 ha of soybean treated annually with the virus. Recently this number dropped down, mainly due to new emerging pests in the soybean complex. Although the use of this virus in Brazil is the most impressive example of bioregulation with viral pesticide worldwide, the virus is still obtained by *in vivo* production mainly by infection of larvae in soybean farms. The demand for virus production has increased tremendously for protection of four million hectares of soybean annually. This high demand for AgMNPV calls for the studies aiming at the sustained inexpensive *in vitro* production of the virus because large scale *in vivo* production of baculoviruses encounters many difficulties. The use of AgMNPV in Brazil brought about many economical, ecological and social benefits.On the basis of this spectacular success of a baculovirus pesticide, it is needless to say that the advantages of biopesticides over chemical pesticides are numerous.

3) Use of bacterial bio-pesticides

Bacterial bio-pesticides are probably the most widely used and cheaper than the other methods of pest bioregulation. Insects can be infected with many species of bacteria but those belonging to the genus *Bacillus* are most widely used as pesticides. One of the *Bacillus* species, *Bacillus thuringiensis,* has developed many molecular mechanisms to produce pesticidal toxins; most of toxins are coded for by several *cry* genes[21]. Since its discovery in 1901 as a microbial insecticide, *Bacillus thuringiensis* has been widely used to control insect pests important in agriculture, forestry and medicine. Its principal characteristic is the synthesis, during sporulation, of a crystalline inclusion containing proteins known as dendotoxins or Cry proteins, which have insecticidal properties. To date, over one hundred *B. thuringiensis*-based bioinsecticides have been developed, which are mostly used against lepidopteran, dipteran and coleopteran larvae. In addition, the genes that code for the insecticidal crystal proteins have been successfully transferred into different crops plants, which has led to significant economic benefits. Because of their high specificity and their safety in the environment, *B. thuringiensis* and Cry proteins are efficient, safe and sustainable alternatives to chemical pesticides for the control of insect pests[22,23]. The toxicity of the Cry proteins have traditionally been explained by the formation of transmembrane pores or ion channels that lead to osmotic cell lysis[22]. In addition to this, Cry toxin monomers also seem to promote cell death in insect cells through a mechanism involving an adenylyl cyclase/PKA signalling pathway[24]. However, despite this entomopathogenic potential, controversy has arisen regarding the pathogenic lifestyle of *B. thuringiensis*. Recent reports claim that *B. thuringiensis* requires the co-operation of commensal bacteria within the insect gut to be fully pathogenic[25,26]. In clear opposition, genomic and proteomic studies have been argued as the most solid data to convincingly demonstrate that *B. thuringiensis* is a primary pathogen rather than a soil-dwelling saprophyte. In any case, what is certainly not doubtful is that *B. thuringiensis* is one of the most successful examples of the use of microorganisms in agricultural biotechnology, with about 70% of the global biopesticide market involving products based on *B. thuringiensis*[27], and will continue to be one of the most important microbial weapons to defend our crops from insect pests. At the end of the twentieth century worldwide sales of bacterial pesticides amounted to about 2% of the total global insecticide market but their share in pesticide market steadily increases.

Organic farming systems rely on approved practices for the control of plant diseases. Approved practices widely used by organic (and conventional farmers alike) include the use of disease resistant/tolerant cultivars and disease reducing cultural strategies, such as crop rotation and sanitation. In addition, composts and organic mulches can be used to help improve crop health in certain situations. Such practices are the cornerstone of integrated disease management; however, they do not always provide an adequate disease control. While conventional farmers can, and often do, use a wide variety of chemical pesticides, certified organic growers may not. Still, there are a number of optional products that organic farmers can use to reduce the incidence and severity of various plant diseases.

B. Plant-Incorporated-Protectants (PIPs)

One approach, to reduce destruction of crops by phytophagous arthropod pests, is to genetically modify plants to express genes encoding insecticidal toxins. The adoption of genetically modified (GM) crops has increased dramatically in the last 11 years. Genetically modified (GM) plants possess a gene or genes that have been transferred from a different species.

The production of transgenic plants that express insecticidal δ-endotoxins derived from the soil bacterium *Bacillus thuringiensis* (*Bt* plants) were first commercialized in the US in 1996. The expression of these toxins confers protection against insect crop destruction[28]. The lethality of *Bt* endotoxins is highly dependent upon the alkaline environment of the insect gut, a feature that assures these toxins are not active in vertebrates, especially in humans. These proteins have been commercially produced, targeting the major pests of cotton, tobacco, tomato, potato, corn, maize and rice, notably allowing greater coverage by reaching locations on plants which are inaccessible to foliar sprays[28]. There are numerous strains of *Bt*, each with different Cry proteins, and more than 60 Cry proteins have been identified[29]. Most *Bt* maize hybrids express the Cry1Ab protein, and a few express the Cry1Ac or the Cry9C protein, all of which are targeted against the European corn borer (*Ostrinia nubilalis* Hubner) (Lepidoptera), a major pest of maize in North America and Europe. Some recent maize hybrids express the Cry3Bb1 protein, which is targeted against the corn rootworm complex (*Diabrotica spp.*) (Coleoptera), also a major pest of maize, especially in North America. Cotton expressing the Cry1Ac protein is targeted against the cotton bollworm (*Helicoverpa zea* Boddie) (Lepidoptera), which is a major pest of cotton; potato expressing the Cry3A or Cry3C is targeted against the Colorado potato beetle (*Leptinotarsa decemlineata* Say) (Coleoptera), which is a major pest of potato; and Cry4 proteins are targeted against some Diptera, such as certain flies (e.g., *Lycoriella castanescens* Lengersdorf) and mosquitoes (e.g., *Culex pipiens* L.).

C. Biochemical pesticides

1) Plant products

Use of botanicals is now emerging as one of the important means to be used in protection of crop produce and the environment from pesticidal pollution, which is a global problem. Neem tops the list of 2,400 plant species that are reported to have pesticidal properties and is regarded as the most reliable source of eco-friendly biopesticidal property. Neem products are effective against more than 350 species of arthropods, 12 species of nematodes, 15 species of fungi, three viruses, two species of snails and one crustacean species [30]. Azadirachtin, a tetranortritarpinoid, is a major active ingredient isolated from neem, which is known to disrupt the metamorphosis of insects[31]. Two tetracyclic triterpenoids - meliantetyraolenone and odoratone isolated from neem exhibited insecticidal activity against *Anopheles stephensi*[32]. Neem Seed Kernel Extract (NSKE) was found most effective in reducing the larval population of

Helicoverpa armigera in chickpea and pod damage[33]. Neem formulations also has a significant effect against eggs of peach fruit fly *Bactrocera zonata* (Saunders). Over 195 species of insects are affected by neem extracts and insects that have become resistant to synthetic pesticides are also controlled with these extracts. The apprehension that large-scale use of neem based insecticides may lead to resistance among pests, as being observed with synthetic pesticides, has not been proved correct. Neem bio-pesticides are systemic in nature and provide long term protection to plants against pests. Pollinator insects, bees and other useful organisms are not affected by neem based pesticides.

Some of the plant products registered as bio-pesticides[34]

Plant product used as biopestcides	Taget Pests
Limonene and Linalool	Fleas,aphids and mites,also kill fire ants,several types of flies, paper wasps and house crickets
Neem	A variety of sucking and chewing insect
Pyrethrum / Pyrethrins	Ants, aphids, roaches, fleas, flies, and ticks
Rotenone	Leaf-feeding insects, such as aphids, certain beetles (asparagus beetle, bean leaf beetle, Colorado potato beetle, cucumber beetle, flea beetle, strawberry leaf beetle, and others) and caterpillars, as well as fleas and lice on animals
Ryania	Caterpillars (European corn borer, corn earworm, and others) and thrips
Sabadilla	Squash bugs, harlequin bugs, thrips, caterpillars, leaf hoppers, and stink bugs

2) Peptidomimetics

Conformationally constrained peptides have been pursued as valuable tools in drug discovery and development, and could be applied in insecticide design. Theoretically, using a non-peptide organic scaffold, the peptide residues critical for binding to the target (‘insectophore’) can be grafted onto a backbone structure to produce a peptidomimetic. This provides a structure that topologically mimics the functional moieties corresponding to the insectophore. This non-peptidic analog has the potential to be used as a lead compound in the development of novel insecticides, overcoming the bioavailability issues of peptides penetrating the insect cuticle or gut mucosa. However, for rational insecticide design, one needs to know both the three-dimensional structure and spatial position of the insectophore, information that is unfortunately lacking with most of the insecticidal toxins characterized to date. Nevertheless the concept has received limited validation following attempts to ‘clone’ the functional residues of peptide toxins that block vertebrate calcium or potassium channels. The development of a peptidomimetic insecticide is likely to be challenging since noncritical residues determined in insect toxicity bioassays may be vital for averting vertebrate toxicity, via steric hindrance. In addition, these non-critical residues maybe important for providing insect target subtype selectivity[35].

3) Use of pheromone in insect pest management

Pheromones are chemicals emitted by living organisms used to send messages to individuals - usually of the opposite sex - of the same species. Pheromones of hundreds of insect species have been chemically elucidated, including the sex pheromone of the codling moth.

When used in combination with traps, sex pheromones can be used to determine what insect pests are present in a crop and what plant protection measures or further actions might be necessary to assure minimal crop damage. If the synthetic attractant is exceptionally effective and the population level is very low, some control can be achieved with pheromone traps or with the "attract and kill" technique. Generally, however, mating disruption is more effective. Synthetic pheromone that is identical to the natural version is released from numerous sources placed throughout the crop to be protected.

Mating disruption has been successful in controlling a number of insect pests. More than 20 percent of the grape growers in Germany and Switzerland use this technique and produce wine without using insecticides. In the United States, mating disruption has proven effective in codling moth, navel orangeworm, pink bollworm, Oriental fruit moth, European grape moth, and grapevine moth, to name a few. More than 40 percent of the fruit tree acres in the western U.S. are treated with mating disruption for caterpillar control. Efforts to control the pink bollworm,*Pectinophora gossypiella* (Saunders), by mating disruption began with the sex attractant "hexalure" in the early 1970's. The discovery of the pink bollworm sex pheromone in 1973 led to the first successful commercial formulation in 1978[36].

An inhibitor-based tactic was demonstrated to suppress infestations of the southern pine beetle, *Dendroctonus* Zimmermann[37]. The southern pine beetle uses a variety of semiochemicals to mediate mass attack on host pine trees. Two aggregation pheromones, frontalin and trans-verbenol, function in directing other beetles to join in the mass attack of a host tree that is necessary for successful colonization. Once the tree is overcome, no further beetles are needed and two anti-aggregation pheromones, endo-brevicomin and verbenone, are released to divert beetles to other trees.

CONCLUSION

Development of biopesticides industry has to be treated as a strategic, comprehensive and forward-looking task.The on going population and the growing need of the population need more supply of the crops and other products. The increasing concern of consumers and government on food safety has led growers to explore new environmentally friendly methods to replace, or at least supplement, the current chemical-based practices. The use of bio-pesticides has emerged as promising alternative to chemical pesticides. Biopesticides have a precious role to play in the future of the Intrgreated Pest Mangement stratagies.

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