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Pheromone technology applications in the cotton fields in Egypt, with special references

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Abstract:

Only 20 years altered the discovery and identification of the first insect pheromone, Bombykol, the silk worm *Bombyx mori* sex – pheromone by Adolf Friedrich Johann Butenandt in 1959 (The Noble Prize in Chemistry 1939, discovery of human female sex – hormones, estrone and other primary female sex hormones, received in 1949) after the discovery of the insecticidal efficacy of DDT , the first chemical insecticide in 1939 by Paul Hermann Muller in 1939 (Noble Prize in medicine 1948). Pheromone technology could be used in many different tactics throughout the integrated pest management (IPM) strategy for the monitoring and control actions of the insect pest complex in the cotton fields. This article emphasizes on the pheromone technology tactics, applications, advantages and benefits in the modern cotton industry.

Introduction

Insecticides are used in agriculture, medicine, industry and the household. The use of insecticides is believed to be one of the major factors behind the increase in agricultural productivity in the 20th century. Nearly all insecticides have the potential to significantly alter ecosystems; many are toxic to humans; and others are concentrated in the food chain. Although the first chemical insecticide (DDT) was discovered it biological activity (Insecticidal activity) in 1939, the first pheromone was (Bombykol) was characterized in 1959, it's only 20 years that altered the pheromones use after the insecticides use.

1. DDT Discovery (Figure 1) :

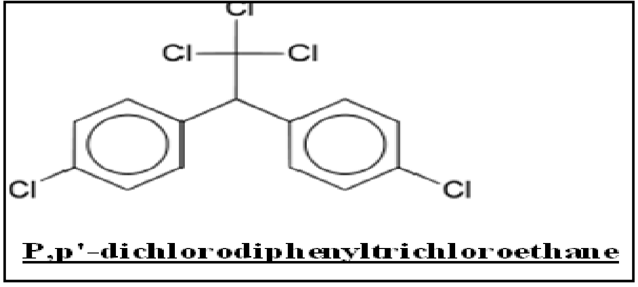


Figure (1) : DDT chemistry

DDT the first of the chlorinated organic insecticides (Figure 1) , was originally prepared in 1873, but it was not until 1939 that Paul Muller of Geigy Pharmaceutical in Switzerland discovered the effectiveness of DDT as an insecticide he was awarded the Nobel Prize in medicine and physiology in 1948 for this discover. The use of DDT increased enormously on a worldwide basis after World War II, primarily because of its effectiveness against the mosquito that spreads malaria and lice that carry typhus. The World Health Organization estimates that during the period of its use approximately 25 million lives were saved. DDT seemed to be the ideal insecticide, it is cheap and of relatively low toxicity to mammals (Oral LD50 is 300 to 500 mg/kg). However, problems related to extensive use of DDT began to appear in the late 1940s. Many species of insects developed resistance to DDT, and DDT was also discovered to have a high toxicity toward fish. The chemical stability of DDT and its fat solubility compounded the problem. DDT is not metabolized very rapidly by animals; instead, it is deposited and stored in the fatty tissues. The biological half-life of DDT is about eight years; that is, it takes about eight years for an animal to metabolize half of the amount it assimilates. If ingestion continues at a steady rate, DDT builds up within the animal over time.

1.1. Insecticide problems :

The heavy use of insecticides almost causes one or more of these problems:

1.1.1. It acts as environmental pollutants.

1.1.2. It has many risks to human health.

1.1.3. It has many side effects on beneficial insects especially natural enemies.

1.1.4. It causes the outbreak of secondary pests.

1.1.5. It causes the problems of what so-called “Insecticide resistance “.

1.1.6. It has a side effects on the treated crops and causes what so-called “ Phytotoxicity “.

1.1.7. It affects the soil fertility.

1.2. Costs of Insecticide problems :

Although, the above mentioned pesticide problems, we have to pay a huge amount of money to overcome some of its side effects. The return on pesticide-intensive agricultural practices has proved unrealized, considering billions of dollars in secondary or externalized costs — from $2.2 billion in annual pesticide poisonings, water treatment and pollination, according to two Iowa State University economists, to $10 billion, according to the research of Cornell University professor David Pimentel.

2. Integrated Pest management (IPM) :

2.1. IPM definitions:

2.1.1. "Integrated pest management, or IPM is a systematic approach to crop protection that uses increased information and improved decision-making paradigms to reduce purchased inputs and improve economic, social, and environmental conditions on the farm and in society. Moreover, the concept emphasizes the integration of pest suppression technologies that include biological, chemical, legal, and cultural controls" (Allen and Rajotte, 1990).

2.1.2. "Integrated pest management (IPM) is a pest management strategy that focuses on long-term prevention or suppression of pest problems with minimum impact on human health, the environment, and non-target organisms". "Preferred pest management techniques include encouraging naturally occurring biological control, using alternate plant species or varieties that resist pests, selecting pesticides with lower toxicity to humans or nontarget organisms; adoption of cultivating pruning, fertilizing, or irrigation practices that reduce pest problems; or changing the habitat to make it incompatible with pest development. Broad spectrum pesticides are used as a last resort when careful monitoring indicates they are needed according to pre-established guidelines" (Flint *et al*., 1991).

2.1.3. "IPM is a system approach based on science and proven crop production and resource conservation practices. It uses all suitable techniques, such as natural enemies, pest resistant plants, cultural management, and pesticides in a total crop production system to anticipate and prevent pests from reaching damaging level " (Bruhn *et al*.,1992).

2.1.4. "Integrated Pest Management is the coordinated use of pest and environmental information along with available pest control methods, including cultural, biological, genetic and chemical methods, to prevent unacceptable levels of pest damage by the most economical means, and with the least possible hazard to people, property, and the environment"(Sorensen, 1993 a and 1994a).

2.1.5. "IPM is an ecologically-based pest control strategy which is part of the overall crop production system. 'Integrated' because all appropriate methods from multiple scientific disciplines are combined into a systematic approach for optimizing pest control. 'Management' implies acceptance of pests as inevitable components, at some population level of agricultural system" (Zalom *et al*., 1992; Gianessi, 1993 ; Saarenmma, 1992; Sorensen, 1993a and Vandeman, 1994).

2.1.6. "Integrated Pest Management, or IPM, involves the carefully managed use of an array of pest control tactics - including biological, cultural, and chemical methods - to achieve the best results with the least disruption of the environment" (EPA, 1993 and AMACSA, 1993).

2.1.7. "Integrated Pest Management (IPM)- A combination of pest control methods (biological, chemical, and cultivation) that, if used in the proper order and at the proper times, keep the size of a pest population low enough that it does not cause substantial economic loss"(Raven *et al*., 1993).

2.1.8. "IPM is a management approach that encourages natural control of pest populations by anticipating pest problems and preventing pests from reaching economically damaging levels. All appropriate techniques are used such as enhancing natural enemies, planting pest-resistant crops, adapting cultural management, and using pesticides judiciously" (USDA-ARS, 1993 and Vandeman *et al*., 1994).

2.1.9. "Management activities that are carried out by farmers that result in potential pest populations being maintained below densities at which they become pests, without endangering the productivity and profitability of the farming system as a whole, the health of the family and its livestock, and the quality of the adjacent and downstream environments"(Wightman, 1993).

2.1.10. "Integrated Pest Management is the judicious use and integration of various pest control tactics in the context of the associated environment of the pest in ways that complement and facilitate the biological and other natural controls of pests to meet economic, public health, and environmental goals"(Cate and Hinkle, 1994 and Wightman, 1993).

2.1.11. "Integrated Pest Management is the use of a variety of pest control methods designed to protect public health and the environment, and to produce high quality crops and other commodities with the most judicious use of pesticides" (CES-UC, 1994).

2.1.12. European Plant Protection Organization has defined integrated Control as "the use of all economically, ecologically and toxicologically justifiable means to keep pests below the economic threshold, with the emphasis on the deliberate use of natural forms of control and preventive measures" (Dehne and Schonbeck, 1994).

2.1.13. "An effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. IPM programs use current, comprehensive information on the life cycles of pests and their interactions with the environment. This information, in combination with available pest control methods, is used to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment. IPM take advantage of all pest management options possible, including, but not limited to the judicious use of pesticides" (Leslie, 1994).

2.1.14."Integrated pest management is a sustainable approach to managing pests by combining biological, physical, and chemical tools in a way that minimizes economic, health, and environmental risks" (NCIPM, 1994; ATTRA, 1995; NFIPME, 1994 and Vandeman *et al.* , 1994).

2.1.15. "Integrated Pest Management (IPM) is an approach to making pest control decisions with increased information and the use of multiple tactics to manage pest populations in an economically efficient and ecologically sound manner**" (Norton and Mullen, 1994).**

2.1.16. "IPM, in its simplest form, is a control strategy in which a variety of biological, chemical, and cultural control practices are combined to give stable long-term pest control." (Ramalho, 1994).

2.1.17. "IPM is a system that controls pests and contributes to long-term sustainability by combining judicious use of biological, cultural, physical and chemical control tools in a way that minimizes the risks of pesticides to human health and the environment" (Sorensen *et al*., 1994).

2.1.18. "Integrated pest management is a pest management system that in the socioeconomic context of farming systems, the associated environment and the population dynamics of the pest species, utilizes all suitable techniques in as compatible manner as possible and maintains the pest population levels below those causing economic injury" (Dent, 1995). This definition was modified from Smith and Reynolds (1966).

2.1.19. " 'Integrated Pest Management' means the selection, integration, and implementation of multiple pest control techniques based on predicted economic, ecological, and sociological consequences, making maximum use of naturally occurring pest controls, such as weather, disease agents, and parasitoids, using various biological, physiological, chemical, and habitat modification methods of control, and using artificial control only as required to keep particular pests from surpassing intolerable population levels predetermined from an accurate assessment of the pest damage potential and the ecological, sociological, and economic cost of other control measures (Florida Statutes 1995, Chapt. 482).

2.1.20. "Integrated pest management (IPM) is the judicious use and integration of various pest control tactics in the context of the associated environment of the pest in a way that compliment and facilitate the biological and other natural controls of pests to meet economic, public health, and environmental goals. Whenever possible, IPM uses scouting, pest trapping, pest resistant plant varieties, sanitation, various cultural control methods, physical and mechanical controls, biological controls, and precise timing and application of any needed pesticides" (Adams, 1996).

2.1.21."Integrated Pest Management (IPM) is a sustainable approach to managing crop pests. IPM combines the use of biological, cultural, physical and chemical tactics in a way that minimizes economic, health, and environmental risks" (FCES, 1996).

2.1.22. "Real IPM: 'A crop protection system which is based on rational and unbiased information leading to a balance of non-chemical and chemical components moving pesticide use levels away from their present political optimum to a social optimum defined in the context of welfare economics'" (Waibel and Zadoks, 1996).

2.1.23. "The management of pests by integrating host resistance, cultural, biological and chemical controls in a manner that minimizes economic, health and environmental risks" (CPM,1997).

2.1.24. " 'Integrated pest management' means a coordinated decision-making and action process that uses the most appropriate pest control methods and strategy in an environmentally and economically sound manner to meet agency pest management objectives. The elements of integrated pest management include: (a) Preventing pest problems; (b) Monitoring for the presence of pests and pest damage; (c) Establishing the density of pest population, which may be set at zero, that can be tolerated or corrected with a damage level sufficient to warrant treatment of the problem based on health, public safety, economic or aesthetic threshold; (d) Treating pest problems to reduce population below those levels established by damage thresholds using strategies that may include biological, cultural, mechanical and chemical control methods and that shall consider human health, ecological impact, feasibility and cost effectiveness; and (e) Evaluating the effects and efficacy of pest treatments" (Oregon Statutes (ORS 262.1), Chapter 943) and McCoy, 1992).

2.1.25. "The management of pests by integrating host resistance, cultural, biological and chemical controls in a manner that minimizes economic, health and environmental risks" (CPM ,1997).

2.1.26. "Integrated Pest Management (IPM) for agriculture is the application of an interconnected set of principles and methods to problems caused by insects, diseases, weeds and other agricultural pests. IPM includes pest prevention techniques, pest monitoring methods, biological control, pest-resistant plants varieties, pest attractants and repellents, biopesticides, and synthetic organic pesticides. It also involves the use of weather data to predict the onset of pest attack, and cultural practices such as rotation, mulching, raised planting beds, narrow plant rows, and interseeding" (Tette, 1997) .

2.1.27. "Integrated Pest Management (IPM) is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistance varieties. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only target organism. Pest control materials are selected and applied in a manner that minimizes risks to human health, beneficial and nontarget organisms, and the environment (UCS-IPM, 1997).

2.1.28. "IPM is a decision support system for the selection and use of pest control tactics, singly or harmoniously coordinated into a management strategy, based on cost/benefit analyses that take into account the interests of and impacts on producers, society, and the environment" (Kogan, 1998).

2.2. IPM (History, Principles and Processes):

2.2.1. History :

Shortly after 1812, when synthetic insecticides became widely available, entomologists in California developed the concept of "supervised insect control. Around the same time, some entomologists in the cotton belt region of the United States were advocating a similar approach. Under this scheme, insect control was "supervised" by qualified entomologists, and insecticide applications were based on conclusions reached from periodic monitoring of pest and natural-enemy populations. This was viewed as an alternative to calendar-based insecticide programs. Supervised control was based on a sound knowledge of the ecology and analysis of projected trends in pest and natural-enemy populations.

Supervised control formed much of the conceptual basis for the "integrated control" that University of California entomologists articulated in the 1950s. Integrated control sought to identify the best mix of chemical and biological controls for a given insect pest. Chemical insecticides were to be used in manner least disruptive to biological control. The term "integrated" was thus synonymous with "compatible." Chemical controls were to be applied only after regular monitoring indicated that a pest population had reached a level (The economic threshold) that required treatment to prevent the population from reaching a level (The economic injury level) at which economic losses would exceed the cost of the artificial control measures.

IPM extended the concept of integrated control to all classes of pests and was expanded to include tactics other than just chemical and biological controls. Artificial controls such as pesticides were to be applied as in integrated control, but these now had to be compatible with control tactics for all classes of pests. Other tactics, such as host-plant resistance and cultural manipulations, became part of the IPM arsenal. IPM added the multidisciplinary element, involving entomologists, plant pathologists, nematologists, and weed scientists.

In the United States, IPM was formulated into national policy in February 1972 when President Richard Nixon directed federal agencies to take steps to advance the concept and application of IPM in all relevant sectors. In 1979, President Jimmy Carter established an interagency IPM Coordinating Committee to ensure development and implementation of IPM practices.

2.2.2. Principles :

An American IPM system is designed around six basic components:

2.2.2.1. Acceptable pest levels:

The emphasis is on control, not eradication. IPM holds that wiping out an entire pest population is often impossible, and the attempt can be expensive and environmentally unsafe. IPM programs first work to establish acceptable pest levels, called action thresholds, and apply controls if those thresholds are crossed. These thresholds are pest and site specific, meaning that it may be acceptable at one site to have a weed such as white clover, but at another site it may not be acceptable. By allowing a pest population to survive at a reasonable threshold, selection pressure is reduced. This stops the pest gaining resistance to chemicals produced by the plant or applied to the crops. If many of the pests are killed then any that have resistance to the chemical will form the genetic basis of the future, more resistant, population. By not killing all the pests there are some un-resistant pests left that will dilute any resistant genes that appear.

2.2.2.2. Preventive cultural practices:

Selecting varieties best for local growing conditions, and maintaining healthy crops, is the first line of defense, together with plant quarantine and 'cultural techniques' such as crop sanitation (e.g. Removal of diseased plants to prevent spread of infection).

2.2.2.3. Monitoring:

Regular observation is the cornerstone of IPM. Observation is broken into two steps, first; inspection and second; identification. Visual inspection, insect and spore traps, and other measurement methods and monitoring tools are used to monitor pest levels. Accurate pest identification is critical to a successful IPM program. Record-keeping is essential, as is a thorough knowledge of the behavior and reproductive cycles of target pests. Since insects are cold-blooded, their physical development is dependent on the temperature of their environment. Many insects have had their development cycles modeled in terms of degree days. Monitor the degree days of an environment to determine when is the optimal time for a specific insect's outbreak.

2.2.2.4. Mechanical controls:

Should a pest reach an unacceptable level, mechanical methods are the first options to consider. They include simple hand-picking, erecting insect barriers, using traps, vacuuming, and tillage to disrupt breeding.

2.2.2.5. Biological controls**:**

Natural biological processes and materials can provide control, with minimal environmental impact, and often at low cost. The main focus here is on promoting beneficial insects that eat target pests. Biological insecticides, derived from naturally occurring microorganisms (e.g.: *Bt*, entomopathogenic fungi and entomopathogenic nematodes), also fit in this category.

2.2.2.6. Responsible pesticide use**:**

Synthetic pesticides are generally only used as required and often only at specific times in a pests life cycle. Many of the newer pesticide groups are derived from plants or naturally occurring substances (e.g.: Nicotine, pyrethrum and insect juvenile hormone analogues), but the toxophore or active component may be altered to provide increased biological activity or stability. Further 'Biology-based' or 'ecological' techniques are under evaluation. An IPM regime can be quite simple or sophisticated. Historically, the focus of IPM programs was on agricultural insect pests. Although originally developed for agricultural pest management, IPM programs are now developed to encompass diseases, weeds, and other pests that interfere with the management objectives of sites such as residential and commercial structures, lawn and turf areas, and home and community gardens.

2.2.3. Processes :

IPM is applicable to all types of agriculture and sites such as residential and commercial structures, lawn and turf areas, and home and community gardens. Reliance on knowledge, experience, observation, and integration of multiple techniques makes IPM a perfect fit for organic farming (Sans artificial pesticide application). For large-scale, chemical-based farms (conventional), IPM can reduce human and environmental exposure to hazardous chemicals, and potentially lower overall costs of pesticide application material and labor.

2.2.3.1. Proper identification of pest - What is it? Cases of mistaken identity may result in ineffective actions. If plant damage is due to over-watering, it could be mistaken for fungal infection, since many fungal and viral infections arise under moist conditions. This could lead to spray costs, but the plant would be no better off.

2.2.3.2. Learn pest and host life cycle and biology. At the time you see a pest, it may be too late to do much about it except maybe spray with a pesticide. Often, there is another stage of the life cycle that is susceptible to preventative actions. For example, weeds reproducing from last year's seed can be prevented with mulches and pre-emergent herbicide. Also, learning what a pest needs to survive allows you to remove these.

2.2.3.3. Monitor or sample environment for pest population - How many are here? Preventative actions must be taken at the correct time if they are to be effective. For this reason, once the pest is correctly identified, monitoring must begin before it becomes a problem. For example, in school cafeterias where roaches may be expected to appear, sticky traps are set out before school starts. Traps are checked at regular intervals so populations can be monitored and controlled before they get out of hand. Some factors to consider and monitor include: Is the pest present/absent? What is the distribution - all over or only in certain spots? Is the pest population increasing, decreasing or remaining constant? This is done through crop scouting. Monitoring should also include the status of the water source being used for irrigation. Water is a breeding house for water borne diseases, and invertebrates, which could potentially contaminate or spread pests, directly onto crops.

2.2.3.4. Establish action threshold (Economic, health or aesthetic) - How many are too many? In some cases, there is a standardized number of pests that can be tolerated. Soybeans are quite tolerant of defoliation, so if there are a few caterpillars in the field and their population is not increasing dramatically, there is not necessarily any action necessary. Conversely, there is a point at which action must be taken to control cost. For the farmer, that point is the one at which the cost of damage by the pest is more than the cost of control. This is an economic threshold. Tolerance of pests varies also by whether or not they are a health hazard (Low tolerance) or merely a cosmetic damage (High tolerance in a non-commercial situation). Different sites may also have varying requirements based on specific areas. White clover may be perfectly acceptable on the sides of a tee box on a golf course, but unacceptable in the fairway where it could cause confusion in the field of play.

2.2.3.5. Use resources to keep up to date on IPM developments. Researchers are always discovering new techniques, and ways to improve old techniques. Keeping up to date gives you the best options available to when using IPM.

2.2.3.6. Choose an appropriate combination of management tactics. For any pest situation, there will be several options to consider. Options include mechanical or physical control, cultural controls, biological controls and chemical controls. Mechanical or physical controls include picking pests off plants or using netting or other material to exclude pests such as birds from grapes or rodents from structures. Cultural controls include keeping an area free of conducive conditions by removing or storing waste properly, removing diseased areas of plants properly, late water floods, sanding ,and the use of disease-resistant varieties. Biological controls are numerous. They include: conservation of natural predators or augmentation of natural predators, Sterile Insect Technique (SIT).

Augmentative control includes the introduction of naturally occurring predators at either an inundative or inoculative level. An inundative release would be one that seeks to inundate a site with a pest's predator to impact the pest population. An inoculative release would be a smaller number of pest predators to supplement the natural population and provide ongoing control.[13] The SIT is an Area-Wide IPM that introduces sterile male pests into the pest population to act as birth control. The biological controls mentioned above should only be used in extreme cases, because in the introduction of new species, or supplementation of naturally occurring species can have detrimental effect to the ecosystem. Biological controls can be used to stop invasive species or pests, or they can be they route by which new pests are introduced. Chemical controls would include horticultural oils or the application of pesticides, such as: insecticides and herbicides. A Green Pest Management IPM program would use pesticides derived from plants, such as botanicals, or other naturally occurring materials. When using any type of chemical control make sure that your pesticide applicator certification is up to day, and that your equipment is well maintained to ensure proper application.

2.2.3.7. Evaluate results - How did it work? Evaluation is often one of the most important steps. This is the process to review an IPM program and the results it generated. Asking the following questions is useful: Did actions have the desired effect? Was the pest prevented or managed to farmer satisfaction? Was the method itself satisfactory? Were there any unintended side effects? What can be done in the future for this pest situation? Understanding the effectiveness of the IPM program allows the site manager to make modifications to the IPM plan prior to pests reaching the action threshold and requiring action again.

2.3. IPM applications in Egypt :

2.3.1. In Egypt, insect pests attack reduced yield and quality of cotton, and oil content in the seeds. The cotton leaf worm (*Spodoptera littoralis* (Boisduval)), the cotton pink bollworm (*Pectinophora gossypiella* (Saund.) and spiny bollworm (*Earias insulana* (Boisduval)) (Lepidoptera, Noctuidae) cause the greatest damage in nearly one million feddans cultivated annually. This study describes an improvement in insect control practices directed against feeding insects (i.e., *S.littoralis*, *P. gossypiella* and *E. insulana*) by integration of insect monitoring, biological control, cultural, behavioral and genetic approaches that can serve as a base for the formulation of biologically- based new approach of integrated management of cotton key pests. Field studies were conducted during 2004 and 2005 cotton seasons at Minia Governorate, middle Egypt, with an experimental area of about 150 feddans of cotton (Giza 80). Five control measures were evaluated: (a) Prediction models based on the Pheromone trap catches; (b) Bio insecticides such Agreen (contains *Bacillus thuringiensis agypti*) and Spinosad; (c) Insect Growth Regulators (Consult: Anti molting compound produced by Dow Agroscience; Cascade: Anti molting compound produced by American Cyanamid; Mimic Molting accelerating compound produced by Rhorm and Haas; (d) Plant growth regulators and Defoliants (Pex: Cotton leaf defoliant and Cytokin: Growth promoting and fruiting hormone compound produced by Rhorm and Haas); (e) Augmentation of *Trichogramma* sp. Various combinations of the tested components were formulated and applied in commercial cotton fields in two successive seasons. Percent of infestations, cotton yield and population density of both natural enemies and sucking pests were used as criteria for evaluation of the various measures. Results showed that: Agreen, trichograma, cascade, consult, mimic, spinosad and conventional insecticides gave reduction in infestation of the three tested pests by 34-75%, 22.1%, 37.7- 75.3%, 33.9- 71.4%, 38.8–74.5%, 67–77.1% and 63.4%, respectively (Amin and Gergis , 2006).

2.3.2. Cotton is the most important crop in Egypt as well as in other countries in the world. Pink bollworm; *P. gossypiella* and spiny bollworm; *E. insulana* are considered the main pests infesting cotton plants. These pests attack the fruit parts of the cotton plants such as buds, flowers and green bolls. This investigation is intended to control bollworms by using sex attractant pheromones with the following objectives in mind: protection of the ecosystem from insecticidal pollution, reducing the insecticides dosages, delaying the emergence of resistance in the pest to the insecticide and to keep the natural enemies which represent the most important factor in the integrated pest management to maintain their role in controlling many pests. The methods of pheromone application used included: a) Pheromone baited traps for the timing of the application (Besides the green boll inspection). This procedure was effective in reducing the infestation rates caused by bollworms from 7% to be less than 2%; b) Mass trapping was effective in reducing the infestation levels with bollworms due to the disturbance in the sex ratio. This method could be utilized at low infestation rates rather than at high infestation levels; c) Attractant and kill technique was implemented to attract the male moths by the pheromone in order to be killed by the insecticide substance in the mixture of pheromone and insecticide. This method reduced significantly the rates of infestation as well as insecticides used in comparison to using insecticides alone for bollworms control (Khider , 2007).

2.3.3. Pink bollworm, *Pictinophora gossypieilla* (Sound.) is the most important pest infesting cotton plants and causing considerable loss of cotton yield in Egypt. The extensive use of insecticides for the pest control had created several problems, such as polluting the environment, development of resistance and disturbance of normal balance between the pests and their natural enemies. The objective of this study was to evaluate some elements of integrated pest management for pink bollworm control. Insects control by the mating disruption technique is achieved by the wide spread application of synthetic pheromone formulation over the crop. The insects are then unable to locate their mates when using their own pheromone and mating activity is therefore reduced. The aim of this work was to protect green bolls from the pest damage. Results revealed that when the application of pheromone is integrated with insecticidal treatments had a highly significant reduction on the green bolls infestation with pink bollworm as compared with using insecticides alone, where the reduction in infestation was around 37%. It was noticed that the predators number in the pheromone treated area was two fold of that in the insecticides treated area. The enzymes activity in the larvae collected from the insecticides treated area was much higher than that in the pheromone treated area because of selection for resistance in the pest due to the extensive use of insecticides. Infestation rates caused by the pest and the insecticides used were higher in the late planting as compared with early planting (Khider , 2007).

3. Bombykol Discovery and the beginning of the pheromone Era (1959):

Bombykol is a pheromone released (Figure 2) by the female silkworm moth to attract mates.

Discovered by Adolf Butenandt in 1959, it was the first pheromone to be characterized chemically. Minute quantities of this pheromone can be used per acre of land to confuse male insects about the location of their female partners, it can thus serve as a lure in traps to effectively remove insects without spraying crops with large amounts of chemicals. Butenandt named the substance after the moth's Latin name *Bombyx mori*.

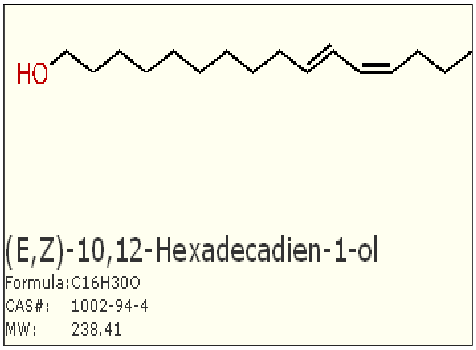


Figure (2): Bombykol chemistry

3.1. Pheromones :

A pheromone (from Greek phero "to bear" + hormone from Greek - "impetus") is a secreted or excreted chemical factor that triggers a social response in members of the same species. Pheromones are chemicals capable of acting outside the body of the secreting individual to impact the behavior of the receiving individual. There are alarm pheromones, food trail pheromones, sex pheromones, and many others that affect behavior or physiology. Their use among insects has been particularly well documented. In addition, some vertebrates and plants communicate by using pheromones. The term "Pheromone" was introduced by Peter Karlson and Martin Lüscher in 1959, based on the Greek word pherein (To transport) and hormone (To stimulate). They are also sometimes classified as ecto-hormones. German Biochemist Adolf Butenandt characterized the first such chemical, Bombykol (A chemically well-characterized pheromone released by the female silkworm to attract mates) (Table 1).

Table (1): Pheromone time line .

Pheromone Time line (1870 - 1990)	
1870	In the 1870s, New York entomologist Joseph A. Lintner suggests the chemical scents emitted by insects could be used to control insect pests.
1870	In the 1870s, French naturalist Jean-Henri Fabre notices a female peacock moth is able to attract 150 male peacock moths from miles away.
1957	German biologist Dietrich Schneider develops the electroantennogram (EAG), a method for using the antenna of a moth to detect pheromones electrically.
1959	German chemist Adolf Butenandt isolates and characterizes the first insect pheromone, that of the domestic silkworm moth.
1959	German biochemist Peter Karlson and Swiss entomologist Martin Lüscher coin the term “pheromone” to describe a compound an animal gives off that triggers a specific behavioral or developmental reaction in a member of the same species.
1960	U.S. Department of Agriculture chemist Morton Beroza reports his idea of using sex pheromones to disrupt insect mating.
1960	In the 1960s, pheromone researchers begin to use gas chromatography, mass spectometry, and nuclear magnetic resonance to identify insect pheromones.
1961	Colin G. Butler identifies the pheromone of the honey bee, the first pheromone that regulates the development of an insect.
1966	Chemist Robert Silverstein and entomologist David Wood demonstrate that all three components of the bark beetle’s pheromone blend are required to attract the beetles—a phenomenon known as synergism.
1967	Entomologist Harry Shorey shows that pheromones can be used to disrupt the mating of cabbage looper moths in the field.
1970	In the 1970s, British biologist John Kennedy develops the wind tunnel assay.
1970	In the 1970s, farmers begin to use pheromones for monitoring insect pests in order to reduce insecticide use.
1971	Wendell Roelofs uses EAG as an analytical tool to identify the codling moth pheromone.
1978	First pheromone is registered in the United States for commercial use in mating disruption—against the pink bollworm on cotton.
1980	Pheromones are used in more than a million traps to capture more than four billion beetles, curbing an epidemic of bark beetles in the forests of Norway and Sweden.
1990	In the 1990s, pheromones used for mating disruption effectively help curb insect damage in stone-pitted fruit orchards, and tomato, rice, cotton, and grape fields.

3.2. Pheromones applications:

The concept of IPM is based on the recognition that no single approach to pest control offers a universal solution, and that the best crop protection can be provided by a fusion of various tactics and practices based on sound ecological principles. Pheromones are a commonly used component of many insect IPM programs.

The existence of pheromones has been known for centuries, apparently originating in observations of mass bee stinging in response to a chemical released by the sting of a single bee. The first isolation and identification of an insect pheromone (Silkworm moth) occurred in 1959 by German scientists. Since then, hundreds, perhaps thousands of insect pheromones have been identified by increasingly sophisticated equipment. Today we have a much clearer view of the limitations and possibilities associated with insect pheromones in IPM programs. The two primary uses of insect pheromones are for detection and monitoring of populations and for mating disruption. These uses take advantage of sex pheromones on which a vast majority of insect pests rely to mediate reproduction.

3.2.1. Uses of pheromones in Integrated Pest Management (IPM) :

3.2.1.1. Detection and Monitoring.

The principle use of insect sex pheromones is to attract insects to traps for detection and determination of temporal distribution. In most instances, it is the males who are responders to female-produced sex pheromones. Trap baits, therefore, are designed to closely reproduce the ratio of chemical components and emission rate of calling females. Ideally, a trap bait should uniformly dissipate its pheromone content over time and not permanently retain or degrade the pheromone in the process. Trap baits of many designs have been tested over the years, but the hollow polyvinyl plastic fiber (Emit from open ends), closed hollow fiber and bag (Emit through walls) and laminated plastic flake (Emit through walls and exposed edges) are commonly used today. Trap design is also critical to effective use of traps for monitoring insect populations. Traps vary in design and size dependent on the behavior of the target insects. Consistent trapping protocols are essential for population evaluations, spray thresholds, and year to year comparisons. The information from trap catches can be very useful for decision making on insecticide applications or other control measures. For example, trap catches may indicate a loss of effect of pheromone on mating disruption and the need to reapply a pheromone treatment. Careful monitoring and experience in interpreting collected data are important for success. Traps may also be placed with the objective of destroying males for population control.

Male annihilation is trapping carried to a seemingly logical conclusion. Place enough traps, catch enough males, and leave the females of the species without mates. This approach has been used against pink bollworms in an isolated area of Arizona with low numbers of overwintering moths. A rate of 5 traps per acre was used and the traps were composed of Styrofoam cups containing oil to provide larger capacity for dead moths. These traps were placed on row centers to avoid the cultivator and never serviced again. The grower community paid for this program for a few years, but results were difficult to prove because a control area was not available. Calculations by Dr. Edward Knipling (USDA retired) indicated that almost all (95%+) male pink bollworms would have to be destroyed before they could mate in order to exert significant population control. Any untrapped males simply mate more frequently. Mating disruption does not depend on traps for control, although traps are frequently used to monitor the extent of mating disruption in the population. Failure to trap males is taken as an indication that males are unable to find females which may or may not be true. Thus, trap data must always be related to actual levels of crop infestation.

3.2.1.2. Mating Disruption. With the commercial availability of insect sex pheromones for several agricultural pests in the 1970's, scientists and entrepreneurs turned their attention to mating disruption as a "Biorational" approach to insect control. In theory, mating disruption may be accomplished in two principle ways: false trail following or confusion (Figure 3) . False trail following results from placing many more point sources of pheromone (Hollow fibers, flakes or other point sources) per acre than the anticipated numbers of females in the crop. The odds of males finding females at the end of the pheromone trail must be greatly reduced. Emission of pheromone is relatively low from each source such that a downwind trail is created and not lost in a background of released pheromone. Males following these trails are thought to spend their mating energies in pursuit of artificial pheromone sources. Pink bollworm males were early observed trying to mate with hollow fiber pheromone sources in treated fields. Thereafter, commercial pink bollworm pheromone products were applied in stickem containing small amounts of a contact insecticide. The resulting attract-and-kill formulations (Another form of male annihilation) were viewed as a subversion of the pheromone by purists, but in practice the damage was limited to the target species. However, the effectiveness of the added insecticide is largely unknown under field conditions. Growers endorsed the idea that a dead male is better than a confused one. A further combination of pheromones and insecticides is occasionally encountered. Dual applications of pheromone and full strength insecticides (Either separately or in tank mixes) are applied with the idea of increasing insect flight activity and thus increasing the chance of insecticide exposure. Full strength applications of pheromone are generally used for this method. The greater the amount of pheromone applied and the greater the release rate, the more likely males are to be confused in the fog of ambient pheromone.

Male confusion is thought to be the result of ambient pheromone concentrations sufficient to hide the trails of calling females (Large doses from diffuse sources such as microcapsules or larger doses of pheromone in point source dispensers such as tie-on polyethylene ropes). Added to the effect, or indeed the effect, is the adaptation of antennal receptor sites and/or habituation of the insect's central nervous system. Specific receptor sites on the antennae respond to only the pheromone molecules (Individual component molecules appear to have individual receptor sites on antennae). When a receptor site is continually activated by high ambient concentrations of pheromones, the resulting electrical signal diminishes (Measured by an electroantennogram). The receptor site becomes unresponsive and the insect becomes navigationally blind. When the insect's central nervous system is inundated with signals from the receptor sites it becomes habituated: no longer able to provide the directed behavior. All of the above are, to some degree, based on known neurophysiology, but exactly what proportion of each occurs in a given situation can only be guessed. The net result of confusion is that the male is unable to orient to any pheromone source and follow the upwind trail to a mate. For a current summary of theory and application of pheromones for control of lepidopterous pests. Present commercial formulations of pheromones for both trap baits and mating disruption mimic the natural chemical blends of females as clearly as possible. Most insect sex pheromones are multicomponent with precise ratios of components which may be expensive to manufacture. Thus, insect sex pheromones and products containing pheromones, are commercially available primarily for insects of economic importance. Fortunately, there is hardly an insect species of agricultural importance, among the Lepidoptera at least, for which there are not some pheromone products available.

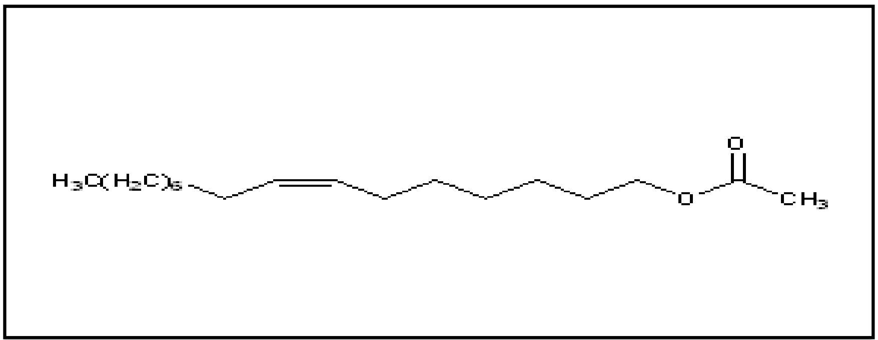
Figure (3) : Pink bollworm *Pectinophora gossypiella* and twist-on spiral mating disrupting pheromone dispenser.

3.3. History of gossyplure applications :

1.3.1. In USA :

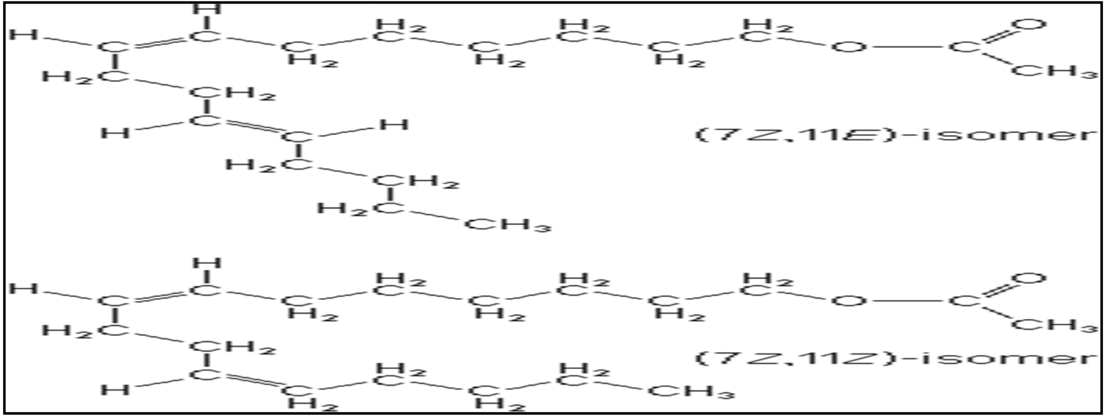
Conventional insecticides have not provided a long-term solution to the pink bollworm problem (Henneberry, 1986). Considerable amounts of basic biological and ecological information have been accumulated and applied in developing PBW control programs. No single control method is completely satisfactory. The possibility of combining a number of methods into a single control system appears to be the most promising approach (Henneberry *et al.*, 1980).

Efforts to control the pink bollworm *P. gossypiella*, by mating disruption began with the sex attractant "hexalure" in the early 1970's (Figure 4) . The discovery of the pink bollworm sex pheromone in 1973 led to the first successful commercial formulation in 1978 (See review by Baker *et al.* (1991). The pheromone, a two component mixture of Z, Z- and Z, E-7,11- hexadecadienyl acetate (Called gossyplure in commercial products) (Figure 5) , has appeared in a variety of aerially applied formulations including hollow fibers, flakes, microcapsules, and in hand-applied twist-tie ropes and twist-on spirals. Original applications utilized 0.75 to 1.5 g AI/acre in several thousand point sources and were applied several times during early to mid-season while recent hand-applied formulations utilized ca. 30 g AI/acre and were applied once. These are known as false-trail following and confusion methods, respectively. All formulations are to be applied at first flower bud ("Pin-square" or about 8 true leaf stage cotton) which is the earliest fruiting form in which the pink bollworm can reproduce. Applications at first flower bud are made against the lowest seasonal (Over-wintered) populations, an aid to efficacy.



Title: Hexalure
CAS Registry Number: 23192-42-9
CAS Name: (*Z*)-7-Hexadecen-1-ol acetate
Additional Names: *cis*-7-hexadecenyl acetate; *cis*-1-acetoxy-7-hexadecene; hexalene
Molecular Formula: C18H34O2
Molecular Weight: 282.46

Figure (4) : Hexalure chemistry .



IUPAC:	1:1 mixture of (7*Z*,11*E*)- and (7*Z*,11*Z*)-hexadeca-7,11-dien-1-yl acetate
	Or
	1:1 mixture of (*Z,E*)- and (*Z,Z*)-hexadeca-7,11-dien-1-yl acetate
CAS:	(7*Z*)-7,11-hexadecadienyl acetate
Reg. No.:	50933-33-0
Formula:	$C_{18}H_{32}O_2$

Figure (5) : Gossyplure chemistry.

Commercial use of pheromone in IPM programs for control of the pink bollworm is widely used in Arizona. The current and perhaps most successful demonstration of the value of this approach is the Parker, AZ, program on ca. 25,000 acres of cotton along the Colorado river in the northwest corner of the state. Deemed to be a somewhat isolated area of the northern extreme of pink bollworm overwintering, the area growers have supported a systematic approach fashioned after the successful boll weevil eradication program. The area-wide program has used selected commercial formulations (Including dual applications with insecticide) to reduce pink bollworm populations each year during the past 5 seasons. The results have been so satisfactory that very little control for pink bollworm is presently needed in the program areas. Systematic IPM programs using pheromone to control pink bollworm are also in use in India and Pakistan but attain the greatest acreage in Egypt. Pheromone treatments totaling a hundred thousand acres, or more were used in Egypt during the 1995 season. Published reports indicate the program of several years is expanding and has produced control of pink bollworm comparable to conventional insecticides. The use of pheromone in Egypt is under state control and is applied to selected large areas of cotton. An overall view of cotton pest management is provided by Luttrell *et al.* (1994).

3.3.1.1. Mating disruption with PBW sex pheromone (Gossyplure):

Behavioral insect control by mating disruption with sex pheromone was suggested by Knipling and McGuire (1966). Hummel *et al.* (1973) identified a mixture of the Z,Z- and Z,E-isomers of 7,11-hexadecadienyl acetate as the pink bollworm sex pheromone and proposed the name “Gossyplure.” Shorey *et al.* (1976) initiated studies to evaluate the mating disruption method, in which the atmosphere of the cotton field was permeated with gossyplure, for PBW control. Albany International Co., Needham, Massachusetts, developed NoMate-PBW®, a slow release formulation of gossyplure and hexane contained in 1.5 cm lengths of about 200 I.D. hollow fibers, sealed near one end (Brooks and Kitterman, 1977). The results of extensive testing in Arizona and southern California indicated substantial reduction in boll infestations and in the need for chemical insecticides for PBW in the NoMate-PBW treated fields (Doane and Brooks, 1980).

Area wide applications with PBW pheromone in the Imperial Valley of California resulted in curtailing insecticide use and significant yield increases (Staten *et al.*, 1983). Additional evaluations of the effectiveness of control of PBW using pheromones in commercial cotton conditions were made in 1981 and in 1982. The gossyplure combination used in these studies included the addition of 0.004 kg of permethrin or fenvalerate (AI) per hectare to the polybutene sticker, Bio-Tac, used to adhere fibers to leaves (NoMate-PBW Attact’n Kill). The addition of this small amount of insecticide was shown to enhance the effectiveness of the pheromone by killing male moths that encountered the fiber (Staten and Conlee, U.S. Patent No. 4671010). The small amount of insecticide, in sources that were attractive only to the pink bollworm and widely scattered (one per 2 m^2) through the top of the cotton canopy, did not appear to be a threat to insect predators.

Hercon Group of Herculite Products, Inc., New York, developed Disrupt®, a slow release system for gossyplure, consisting of three-layer plastic dispensers (0.05 cm^2) with gossyplure concentrated in the center reservoir and the outer layers regulating the release of the pheromone. The results of field tests of this product in Arizona indicated substantial reduction in boll infestations (Henneberry *et al.*, 1981). Shin-Etsu Chemical Co., Ltd, Tokyo, Japan, developed the PB-

Rope®, a high-rate, slow release system consisting of a wire-based, sealed polyethylene tube (8") filled with gossyplure. Extensive field trials conducted in the Imperial Valley of California and the Mexicali Valley of Mexico indicated a substantial reduction in boll infestations and insecticide applications in the PB-Rope treated fields, compared with that in conventional insecticide-treated fields (Staten *et al*., 1987). Community-wide application of the PB-Rope in the Coachella Valley of California, at the pinhead square growth stage, provided a highly effective level of control of PBW for approximately sixty days, and insecticide usage was drastically reduced or even eliminated in some fields (Staten *et al*., 1988). Area wide, timely application of commercial formulations of gossyplure in the Parker Valley of Arizona, demonstrated the feasibility of suppressing PBW infestations to a near zero level in four years, and conceptualized the prospect of eradication (El-Lissy *et al.*, 1993; Staten *et al*., 1995; Antilla *et al*., 1996 and Grefenstette *et al*., 2009).

3.3.1.2. Combining gossyplure and insecticides :

Gossyplure, the pink bollworm sex pheromone, has been used commercially since 1977 to suppress pest populations by disrupting mating in cotton crops. Two slow-release systems for gossyplure are commercially available: No- Mate PBW fibers and Disrupt flakes, suspended in the sticker Bio-Tac or Phero-Tac, respectively, and applied aerially with special equipment. The addition of small amounts of pyrethroid insecticide to the sticker has been suggested to kill male pink bollworm moths attracted to and contacting the pheromone-sticker combination (Point source). To determine the effectiveness of such treatments, we conducted tests in cooperation with growers and pest control advisors in southeastern California's Palo Verde Valley. Catches of male pink bollworm moths (*P. gossypiella*) in gossyplure baited traps, rosetted blooms and boll infestations, and numbers of beneficial predators were compared in fields treated with: (a) Disrupt with and without the pyrethroid insecticide permethrin in Phero-Tac; (b) NoMate PBW with and without permethrin in Bio-Tac; and (c) Insecticides only (Trichlorfon). Some decisions to treat or not to treat were made jointly by the chemical representatives, grower, and pest control advisors. Others were made routinely by grower's pest control advisor. This is a report of the 1982 studies (Beasley and Henneberry, 1984) .

3.3.2. In Egypt:

In 1999, in the Governorate of Fayum, Egypt, an organically managed area of 66 ha (33 ha of cotton) was subjected to pheromone mating disruption (MD) in order to control *P. gossypiella* (PBW). Tripherone-PecGos dispensers (Trifolio-M Comp., Lahnau, Germany), evaporating 0.7 mg pheromone per day, were applied, at a density of 300 dispensers per hectare, in mid-June when the first bolls were forming. In a neighboring area of conventional agriculture, no PBW-MD was used. Instead, two insecticides were sprayed in the cotton fields: Profenophos in early July, and Esfenvalerate in early August. Two cotton fields (0.5–1 ha each) were studied in each area. Boll infestation by PBW was low in the area with mating disruption, and significantly higher in the conventionally managed cotton, prior to insecticide use (June) and in August 1999. *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) *Aphis gossypii* (Glover) (Hemiptera: Aphididae) and *Empoasca lybica* (de Bergevin) (Hemiptera:Cicadellidae) infested conventional cotton in significantly higher numbers than organic cotton. Spiders proved to be more common in organically grown cotton (With PBW-MD) than in conventionally managed cotton (With mineral fertilizers and insecticides). The reasons of these differences are discussed. In 1998, the cotton yield had shown no differences between organically and conventionally managed farms (both used insufficient PBW-MD). However, in 1999, the yield from the organically grown cotton (With MD) was significantly (52%) more than that from conventionally managed cotton (With insecticides). In this study, PBW-MD proved to be superior to insecticides in several aspects (Boguslawski and Basedow, 2001).

3.3.2.1. Different Pheromone tactics applied in Egypt:

Pheromones strategy differs completely in its tactics than the insecticide strategy (Because of their different aims and targets). In Egypt, pheromone strategy was used widely with many different tactics as an important part of the IPM program conducted then. Some of these tactics are:-

3.3.2.1.1. Pheromone traps for monitoring and detection technique :

3.3.2.1.1.1. The use of pheromone traps, of different types and shapes, for monitoring insect pest field population density and dynamics over place (Village, district, Governorate, region, countrywide), (Campion *et al.*, 1978; Campion *et al.*, 1980; Doane and Brooks, 1980; El-Sayed *et al.*, 1984; El-Deeb *et al.*, 1987; Albeltagy *et al.*, 1991a; Hosny *et al.*, 1991; Khider *et al.*, 1991 and Albeltagy, 2012 a).

3.3.2.1.1.2. The use of pheromone traps, of different types and shapes, for monitoring insect pest field population density and dynamics over time (day, week, month, season, year), (Albeltagy *et al.*, 1993a).

3.3.2.1.1.3. The use of pheromone traps, especially delta traps, as a control indicator to differentiate between different kinds of control actions as a mean of IPM (Albeltagy *et al.*,1996a).

3.3.2.1.1.4. The use of pheromone traps, especially delta traps, as a control trigger for insect pest control decision for different kinds of control actions as a mean of IPM, (Albeltagy, 1999).

3.3.2.1.1.5. The use of pheromone traps, especially delta traps , to evaluate the pheromone release rates and its corresponding effect on crop infestations (Albeltagy *et al.*, 1993 c) .

3.3.2.1.1.6. The use of pheromone traps, especially delta traps, to indicate the relationship between trap catches and crop infestation (Albeltagy *et al.*, 1995 a).

3.3.2.1.1.7. The use of pheromone traps, especially delta traps, to build up computer simulation models for different insect pest control strategies and tactics (Albeltagy *et al.*, 1995b) .

3.3.2.1.2. Pheromone traps for mass trapping technique :

3.3.2.1.2.1. The use of many different pheromone trap types (delta, funnel and / or water) as a mass trapping technique against many different insect pest field strains (Campion and Nesbitt, 1981; Crithley and El-Deeb, 1981; Albeltagy *et al.*, 1991b and Hamid and Albeltagy, 1995; Khider, 1997 and Albeltagy 2012a).

3.3.2.1.3. Pheromone disruption technique:

3.3.2.1.3.1. Pink bollworm (PBW) rope gossyplure (The sex pheromone of PBW) formulation was used against pink bollworm on large scale applications (thousands of acres) in cotton fields for many years (Albeltagy, 1993 and Albeltagy *et al.*, 1993 b) .

3.3.2.1.3.2. The use of pheromone disruption technique as a part of IPM program against cotton insect complex pests (Albeltagy *et al.*, 1993d) .

3.3.2.1.3.3. The use of pheromone disruption technique as a part of IPM program to enhance the role of biological control agents in cotton fields.

3.3.2.1.3.4. The use of different pheromone confusion techniques, disruption – lure and kill, in different formulation types (Dispensers, rubbers and microencapsulated) (Brooks *et al*., 1979; Kydonieus and Beroza, 1981; Hall *et al*., 1982; Campion, 1983; Critchley *et al*., 1983; Critchley *et al*., 1985, Khider *et al*., 1986; Gadallah *et al*., 1990; Abdo *et al*., 1991 ; Moawad *et al*., 1991 ; Albeltagy and Haroun, 1996 and Albeltagy, 2012a) .

3.3.2.1.4.Attracticide resistance monitoring technique(ARMT) :

3.3.2.1.4.1. The use of pheromone traps in the attracticide resistance monitoring technique as a simple, easy , effective, accurate, and quick tool for monitoring and detecting insecticide resistance in insect pest field populations (Tables 2 and 3) (Albeltagy *et al*., 1996 b ; Albeltagy *et al*., 2000 ; Khider *et al*., 2002; Albeltagy *et al*. , 2010 and Albeltagy, 2012b)

Table (2): Pheromone treated area in Egypt.

#	**Year**	**Cotton area**	**Pheromone area**	**%**
		(Feddan)	(Feddan)	
1	1982	1,065,841.00	500.00	0.05
2	1983	998,277.00	1,250.00	0.13
3	1984	983,560.00	13,000.00	1.32
4	1985	1,081,009.00	37,000.00	3.42
5	1986	1,054,860.00	61,000.00	5.78
6	1987	969,793.00	6,000.00	0.62
7	1988	1,013,960.00	30,000.00	2.96
8	1989	1,005,533.00	40,000.00	3.98
9	1990	993,047.00	0.00	0.00
10	1991	851,283.00	7,500.00	0.88
11	1992	840,296.00	40,000.00	4.76
12	1993	884,310.00	100,000.00	11.31
13	1994	721,443.00	360,000.00	49.90
14	1995	710,207.00	500,000.00	70.40
15	1996	920,911.00	550,000.00	59.72
16	1997	859,255.00	590,000.00	68.66

Table (3): Gossyplure formulations used in disruption technique in Egypt.

Campany	**Product**	**Formulation**	**Concentration**	**Application rte**	**a.i. (gm)**
			a.i.(gm)/L. or Kgm	**/ feddan**	**/ Feddan**
ICI	Pectone	Microencapsulated	20	200 ml	4
Sandoz	Nomate	Hollow Fiber	76	15 gm	1.14
Bassif	Hircon	Micro flakes	28	60 gm	1.68
Feromone	Stirrup	Concentrated liquid	6.32 gm	240 ml	1.52
Somotomo	Pb-Rope	Long tube	1 = 144 mgm	150 tube	21.6
Ecogen	Nomate	Gelatin Ring	1 = 155 mgm	200 ring	31
Agrisence	Sellibete	Rubber ring	1 = 254 mgm	104 ring	26.4
Feromone	Lastfight	Poly- metric Paste	1 = 73 mgm	300 drop	22

4. Advantages of pheromone applications :

4.1. Decreases number of insecticide applications.

4.2. Rationalizes insecticides usages.

4.3. Keeps the susceptibility of insect pest field populations.

4.4. Keeps the efficiency of insecticides.

4.5. Increases pollinators.

4.6. Increases crop productions.

4.7. Decreases environmental pollutions.

4.8. Enhances biological control agents.

4.9. Increases honey- bee populations and honey productions.

4.10. Increases farmer benefits.

5. Recommendations :

We must expand in using pheromone technology tactics for insect pest management (IPM) in different agricultural crops (Especially cotton) and horticultures, and also against medical and livestock insect pests as mentioned previously to obtain these results :-

5.1. To overcome the above mentioned pesticide problems.

5.2. To gain the advantages of pheromone technology use.

5.3. For farmers to gain good profits of their cultivations, instead of their annual losses .

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