Research & Reviews

ISSN: 2319-9857

Research and Reviews: Journal of Agriculture and Allied Sciences

# The Cotton Bollworms: Their Survey, Detection and Management through Pheromones: A Review.

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## Short Communication

Received: 24/06/2013
Revised: 27/06/2013
Accepted: 02/07/2013

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**Keywords:** Cotton, pheromone, bollworm, *Pectinophora gossypiella*

**ABSTRACT**

Cotton is the backbone of agrarian economy and the textile industry throughout the world. There are many reasons for low yield of cotton crop- high price of agriculture inputs (seeds, fertilizers, pesticides), higher intensity of insects and pests attack, shortage of good quality and varieties of seeds, deficiency of water for irrigation, lack of advance technologies, its awareness and agro-professionalism, and adulterations in pesticides, fertilizers and seeds. Among other constrains, one important cause is the attack of insect pests, therefore, it has become vital for Pakistan and other countries to increase cotton yield per acre against pest ravages. Pheromone traps are used to monitor the presence of pests, as control tools to capture insects, as confusants to disrupt insect mating and as lures to attract insects to insecticidal baits. Present article describes alternative control strategies of cotton bollworms such as mating disruption with synthetic pheromone for its potential role in integrated pest management.

## INTRODUCTION

Cotton is an important crop around the world which comes from the cotton plant that produces fibers which are used to make clothes and other products. Cotton fiber today is the most used textile yarn in the world. The natural fiber of cotton finds it uses in many products, these range from clothing to home furnishings and medical products. The short fibers can be used in the paper industry and the long cotton fibers are used to make cloth [1]. Each cotton fiber is composed of concentric layers. The cuticle layer on the fiber itself is separable from the fiber and consists of wax and pectin materials. The primary wall- the most peripheral layer of the fiber, is composed of cellulosic crystalline fibrils. The secondary wall of the fiber consists of three distinct layers. All three layers of the secondary wall include closely packed parallel fibrils with spiral winding and represent the majority of cellulose within the fiber. The innermost part of cotton fiber- the lumen is composed of the remains of the cell contents. Before boll opening, the lumen is filled with liquid containing the cell nucleus and protoplasm. The twists and convolutions of the dried fiber are due to the removal of this liquid [2]. Out of the seeds of the cotton plant, oil or margarine can be made. The leaves and stalks of the cotton plant are ploughed into the ground to make the soil better fertile. Other parts of the cotton plant are fed to animals systems [3].

Cotton is the important non-food cash crop and a significant source of foreign exchange earnings for Pakistan which contributes significantly to the national economy. As a result, cotton is always in demand due to its uses which is a subject to give the strength to weakness of the overall economy. It accounts for 6.9 percent of value added in agriculture and 1.4 percent of GDP. In addition to provide raw material to the local textile industry, the lint cotton is an export item. During 2010-11, the crop was cultivated on an area of 2689 thousand hectares, which is 13.4 percent less than last year (3106 thousand hectares). The production is estimated at 11.5 million bales, lower by 11.3 percent over the last year's production of 12.9 million bales, and 17.9 percent less than the target of 14 million bales. The decrease in its cultivated area and production is attributed to loss in area under cultivation due to floods, widespread attack of Cotton Leaf Curl Disease (CLCuD) and sucking pest/ insect in core and non-core areas [4].

In cotton production, there are many factors that can reduce crop yield and one important cause is the attack of insect pests. Insect pests' attacks reduce yield and quality of cotton, and oil content in the seeds. Cotton is vulnerable to an extensive array of insect

ISSN: 2319-9857

pests and among these the cotton bollworms are the most destructive fatality. A number of caterpillar species feed on the squares and bolls of the cotton plant. The cotton leaf worm (*Spodoptera littoralis*), the cotton pink bollworm (*Pectinophora gossypiella*) and spotted or spiny bollworms (*Earias insulana* & *Earias vitella*) cause the greatest damage [5]. Among these bollworms, pink bollworm is the most serious, because once the damaging stage (larvae) enter the bolls, it becomes very difficult to control with insecticides. It is distributed all over the cotton growing countries of Asia, Africa, Australia, USA, India and Pakistan. The other two species of bollworms tend to cause more conspicuous damage particularly to newly developing fruiting bodies and the terminal shoots. As a result, the fruiting bodies are shed and lateral shoots are produced which result in de-shaping of cotton plant. In all the three species, eggs are laid singly on fruiting bodies and the larval developments take place almost entirely within the flowers or bolls and badly affect the quantity and quality of the lint. In spite of the pests, insect management is the utmost inconsistent and price linked operation with the production of cotton crop. Control of these pest species with conventional insecticides, is difficult due to high cost and inaccessibility. Taken as a whole, the objective of the caterpillar insect pests management study plan is to build up and estimate pest management approaches that are environmentally acceptable and cost effective. Areas of research comprise development of insect threshold, better understanding of the pest's ecology and biology, management of resistance in pests, development of methods to avoid insect pest problems through crop management, effectiveness of crop protection products, use of resistant varieties, and molecular genetics. The emphasis should always be placed on integrated pest management (IPM) techniques to promote ways to grow clean, chemical and pesticide free cotton that are the most hazardous to human and animal health.

There has been an increasing interest in more environmentally friendly alternatives to the use of pesticides in cotton due to health and environmental concerns. A vast planting of transgenic cotton producing insecticidal proteins from the bacterium *Bacillus thuringiensis* (Bt) have helped to control several major insect pests to reduce the need for insecticide sprays. Because broad-spectrum insecticides kill arthropod natural enemies that provide biological control of pests, the decrease in use of insecticide sprays associated with Bt cotton could enhance biocontrol services. A marked increase in abundance of three types of generalist arthropod predators (ladybirds, lacewings and spiders) and a decreased abundance of pests associated with widespread adoption of Bt cotton, and as a result reduced insecticide sprays in this crop have been shown [6, 7]. It has also been found evidence that the predators might provide additional biocontrol services spilling over from Bt cotton fields onto neighboring crops. On the basis of data, the work extends results from field studies by evaluating biological effects of predators on cotton by demonstrating that such crops can promote biocontrol services in agricultural landscapes [8]. This study describes an improvement in pest control practice directed against feeding insects of cotton i.e., cotton bollworms.

The controlled release of pheromones can be used as part of an Integrated Pest Management Program to minimize the quantity of pesticides used. Pheromones are the chemicals secreted by an organism that elicit a behavioral response from other organisms of the same species, especially substances that act as sex attractants. Sex pheromones may be produced by females or by males according to the species. In most insects, the pheromones are secreted into the external environment by female to attract males for mating. Pheromones may signal information as diverse as the sexual receptivity of the producer, perceive dangers or the dominance of an individual in a colony. Researchers have interfered with these communication systems as a mean to selectively control or manage pest species in agricultural and forest systems [9]. Pheromone is secreted externally by an insect to influence the behavior of other members of the same species or carrying out as an attractant of the opposite sex. The application of pheromones is a very compatible component of bio-control technology. The integration of biological and behavioral control through pheromones may prove effective for the management of cotton bollworms [10]. Such method is based on the fact that the males and females of many insect species rely on sex pheromone communication in order to come together and perform various essential courtship behaviors before mating. Permeating the insect's environment with synthetic sex pheromone could prevent the females to mate and thus, not to lay viable eggs. The use of synthetic pheromone as a direct means of insect control in various insect species has been proposed by many workers. The use of sex pheromones include identification of pheromones, development of dispensers and traps, assessment of pheromone traps as a monitoring device, and the use of pheromones for mating disruption [11]. The male moth catches in gossyplure-baited traps were used to predict larval infestation of pink bollworm *P. gossypiella*, in cotton fields [12].

The chemical status of the female sex pheromone of pink bollworm was identified as a mixture of the two Z, Z- and Z, E- isomers of 7, 11- hexadecadienly acetate and proposed the name "Gossyplure" during 1973. It was observed that 1:1 ratio of the two isomers of gossyplure is the most effective in attracting the pink bollworm male moths. The major component of the sex pheromone of spiny bollworm *E. insulana*, was identified as (E, E) - 10, 12- hexadecadienyl in 1980. In 1986 it was reported that traps baited with 1 mg of the synthetic sex pheromone of spiny bollworm has good potential for monitoring the moth population in the field. The spotted bollworm *E. vittella*, pheromone was identified as a mixture of 2:10:2 of (Z)-11-hexadecenal, (10E, 12E)-10, 12-hexadecadienal and (Z)-11-octadecenal in 1988 and it attracted as many males as the virgin female [13, 14]. Since that time, these pheromones have been used for survey, detection and monitoring to determine the need for control action, mating disruption, and mass trapping.

Survey improvement has been directly related to the trap design and pheromones. The uses of pheromones to detect low density populations of bollworms have provided a better insight into the seasonal distribution of the insects. Experiments conducted at Nuclear

ISSN: 2319-9857

Institute of Agriculture (NIA), Tando Jam, indicated that pink bollworm moths were caught every month of the year with gossyplure baited traps, though catches were extremely low from May to July. Previously, available detection system caught moths only during the cotton growing season; that is during periods of relatively high population density. Studies gave an indication that probably pink bollworm does not enter in true diapause due to milder winter season in lower Sindh. The activity of spotted and spiny bollworms was also observed throughout the year. The peak moth population of spotted bollworm was in the month of August where as the maximum spiny bollworm moth population activity had been observed in the month of October.

The method of using gossyplure baited traps for monitoring pink bollworm population to determine the need for control action has been developed in cotton fields. Significant reduction in numbers of insecticide applications and cost has been reported when treatments for pink bollworm control were based on male moth catches in pheromone baited traps technique as compared to old five-seven-day insecticide spray schedules. Pheromone baited traps have proved an important and easy sampling tool in Integrated Cotton Pest Management System. Experiments conducted at same Institute, manifested that a mean trap catches of 9-12 moths per night of pink and spotted bollworms were associated with economic injury level of infestation of each species. In case of spiny bollworm, although, a maximum of 12 moths were captured per trap per night in the month of October, but the infestation remained below economic threshold i.e. with 10% damage. It was concluded that insecticidal sprays may be scheduled successfully when 9-12 moths of cotton bollworms are captured per trap per night.

Work on the use of pheromone for mating disruption was initiated in 1976, with gossyplure to evaluate this concept as a practical and effective technique for pink bollworm control. Promising results by using different type of pheromone evaporators to disrupt mating and prevent population development in bolls have been reported. Mating disruption technique was fully registered by the Environment Protection Agency of different countries for the control of pink bollworm in cotton. Control of pink bollworm using pheromones by mating disruption has been successfully demonstrated in USA, Egypt and Pakistan. However, in Pakistan, spotted and spiny bollworms required a specific insecticide treatment following the application of pheromone for pink bollworm. With the identification of pheromones of spotted and spiny bollworms, a single hand application of their combined pheromones has been developed in twist-tie dispenser formulation. Experiment conducted at NIA, Tando Jam showed no significant differences in yield of seed cotton obtained from plots treated with combined pheromones of the three bollworm species compared with plots receiving conventional insecticide treatments. Similar types of results have also been reported from Multan.

Mass scale trapping of male pink bollworms with gossyplure baited traps to reduce mating success and population development has also been studied and reported for having potential effect for pink bollworm control. The early-season, area-wide mass trapping programme resulted in 3 years average pink bollworm larval infestation of 1.9% as compared to 4.2% average for 3 years prior to the trapping programme. It has been reported that the lower pink bollworm infestation during the trapping period occurred in the absence of cultural or weather changes and indicated that the mass trapping technique had potential as a tool in pink bollworm pest management systems. Both the techniques, the mating disruption and mass trapping (male annihilation), were compared at NIA, Tando Jam and it was observed that mating disruption technique was significantly better than mass trapping system.

Pheromones and baited traps have improved substantially the survey and detection of low density populations for monitoring insect population to determine the ardent need to control action against the three bollworm species of cotton generally available in Pakistan. The catches of adult moth in pheromone baited traps are an effective pest management tool in reducing the insecticide use and cost of control. Many factors such as weather, population density, condition of crop and trap design may affect the catches of bollworm moths in traps. Therefore, more research is needed to be conducted to trap the moths in terms of above variables. The mating disruption technique has proved effective to control the three bollworm species and has an advantage over the insecticidal control method in being species specific, non-polluting and non-hazardous. It does not disturb the beneficial insect fauna, which prevents the eruption of secondary pests in the environment. However, for mating disruption methodology, large amounts of lures are required. The efforts should be made to make the pheromone formulations easily available and less expensive, so that these can be within the reach of the farmers as these pheromone formulations are easier to apply and reduce the possible build up of pesticide resistance by insect pests.

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