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Checkmate the Pink Bollworm

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This article is meant to sensitise the non-technical reader to the term pheromone. 'Pheromone' derived from the Greek word 'pherein' meaning 'to convey' with 'mone' from 'hormone', is a chemical substance produced and released into the environment by an animal, especially a mammal or an insect, affecting the behaviour or physiology of others of its species. Pheromones are intra-specific in action and therefore are safe to natural enemies. Pheromones are predominantly volatile, but sometimes are liquid, contact chemicals. All are produced by exocrine glands. Pheromones are effective in very small quantities and are categorised as sex pheromones, alarm pheromones, aggregating pheromones, trail marking pheromones, spacing pheromones, etc. Sex pheromones and its use are discussed in this article in the context of pink bollworm management. The sex pheromone in the pink bollworm called gossyplure, is emitted by the female and is responsible for attracting the male for the purposes of mating. Male moths are active before female moths on a daily and seasonal basis and synthetic pheromones can intercept and trap male moths before calling begins. By itself, pheromones are not toxic and do not kill through properties such as those possessed by insecticides. They have been exploited for management of insect pests such as the Gypsy moth, Codling moth, Med Fly, Japanese Beetle and the Pink bollworm.

GUEST COLUMN

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Semio-chemical pest management programs in crops deploy pheromones as lures for one or more of the following: monitoring, mass trapping, mating disruption and as lure and kill. Pheromones are rarely used as a standalone management tool. They are used in combination with other interventions for effective and timely pest management.

Monitoring

PBW sex pheromone, gossyplure is used to quantify the influx of moths into a given area over a specified period, so as to time the control measure when the vulnerable stage, larvae in this case, are best targeted. Monitoring should begin well before the pest becomes established in a given area. It should be done to ensure the utility of an expensive control measure. Monitoring using pheromones is best carried out for pink bollworm, a pest whose trap catches correlate well with larval damage in green bolls. Eight moths per trap per night over three consecutive nights, is the economic threshold level at which pest control actions must

1. Moth of Pink Bollworm

3. Moth catches collected in pheromone trap

2. Pheromone trap with moth catches

4. Pink bollworm damage on green boll

be initiated to prevent economic damage. The association between pink bollworm moth captures and boll infestation was positive and significant for non-Bt cotton fields but was not significant for Bt cotton fields in the US. This is not true with Bt resistant pink bollworm in parts of India.

Mass Trapping

Mass trapping of insects is meant to remove insects from breeding and feeding. The insect must find and contact the pheromone source. A suitable trap design is essential to handle large volumes of trapped adult moths. Efficacy of mass trapping depends on the density of the natural (virgin females) and synthetic pheromone that is used. It can be timed after or before a control measure, such as the use of insecticide. Eradication of new invasions of insect species is affected by this method. Mass trapping works well at low pest densities. The density and efficiency of traps as well as the strength of lures needs to be sufficient to catch enough insects to reduce economic damage. Mass trapping can be used as a standalone pest management tool or can be coupled with the use of insecticides either before or after the process of mass trapping.

Sticky or oil traps baited with 1 mg of gossyplure at a density of 10-20 traps per hectare were deployed in cotton fields with lure replacement every 2-3 weeks in Brazil.

The success of large-scale mass trapping against pink bollworm in the Brazil trial was attributed to: 1) low population present early in the cotton growing season, 2) cotton growing area needs to be isolated, and 3) other cotton pests do not cause severe problems.. Mass trapping has been used in long-term pest management [e.g., codling moth, *Cydia pomonella* (L.); pink bollworm, *Pectinophora gossypiella* (Saunders); bark beetles, palm weevils, corn rootworms (*Diabrotica* spp.); and fruitflies] or in eradication of invasive species [e.g., gypsy moth, *Lymantria dispar* (L.); and boll weevil, *Anthonomus grandis* Boheman). However latest reports suggest that mating disruption is more effective than mass trapping to control pink bollworm.

Lure and Kill

This involves the use of pheromone to lure and insecticide/ sterilant/ insect pathogen to kill / sterilise/infect the lured insect. In this method the insect is not trapped as in mass trapping but is killed/sterilised or infected, instead. This method should be adopted from the time of first adult to last adult emergence and is less effective at higher pest densities due to greater number of calling wild females. Pyrethroids are commonly used to kill the lured moths. When the male pink bollworm is lured by the pheromone and touches the pyrethroid treated surface, not only does it die in 24 hours, its flight behaviour is significantly affected, preventing it from locating a female.

Mating Disruption

Preventing pheromone communication between sexes by saturating the area with high concentration of pheromone, thus disrupting mating, is the basic principal of this method. The sex that responds to the pheromone is unable to find the sex that is emitting it. Insects remain alive, but are disoriented and do not mate and therefore do not breed. Male moths that come in contact with the pheromone and fly away also become a potential source for emitting the pheromone, having acquired it through contact, further aiding in mating confusion. This method is recommended for use in cotton grown in the US, from the six node growth stage, i.e. before the pinhead stage.

Strategy of Pheromone Use for PBW Management

USA: An area wide pink bollworm eradication program, categorised into three phases, and executed between 2001-2008, involving growers and federal agencies was proposed. Operational elements involved mapping to identify field locations, quantify the acreage and determine the genotypes. Detection by trapping (one trap per 10 acres with each trap having rubber septa impregnated with 4mg of gossyplure) and visual inspection (10 randomly selected non Bt fields per work unit of 12000-15000 acres) inspected weekly at bloom stage for rosette bloom. This was associated with larval surveys at green boll stage. Cultural control practises, mating disruption was associated with sterile insect release and cultivation of Bt cotton with minimal insecticides. Community wide application of the PB Rope R a commercial pheromone formulation at pin head square growth stage offered effective control of PBW for 60 days. This was accompanied by release of sterile males of pink bollworm into the environment. One hundred sterile moths per acre per day at 4 leaf growth stage were released on all conventional cotton fields.

When larval infestation exceeded 5% chlorpyriphos @0.75lbs/acre (0.85 kg/ha) was applied. Cultural control involving shredding and ploughing of earlier crop reduced moth emergence by 80%. This killed diapausing larvae in late season bolls, trash and soil. Practised along with uniform planting, harvesting and off-season irrigation limited pink bollworm incidence and damage in cotton. Phase I was implemented over 55000 acres that increased to 250,000 acres each in the second and third phase.

Egypt: Mating disruption was carried out using P B Rope L. One thousand PB Ropes were dispensed per hectare, 200mm long with a diameter of 25mm impregnated with 78mg of gossyplure. The COT plant and insect simulation model was initialised for the main long staple cotton varieties (Giza'75 and Giza'80) and for the release rate characteristics of several pheromone formulations and dispenser types. When primed with the magnitude of the spring bollworm emergence and certain agronomic data, the system predicted bollworm populations for given field management scenarios.

5. PB Rope L on cotton plant

Simulations have proved accurate and useful but have demonstrated problems with the use of pheromone traps as control decision tools.

India: Pink bollworm emerged as a major problem on cotton due to the cultivation of Bt hybrids of variable duration almost all through the year as large contiguous tracts with selection of the worm first on Cry 1Ac and then to the combination of toxins Cry1Ac+Cry2Ab. Field resistance is not recorded yet, in North Indian populations of the pink bollworm largely due to synchronous sowing and crop termination to facilitate timely sowing of the succeeding wheat crop. Cultivation of short duration Bt varieties is an imminent necessity especially in Central and South India where Bt resistance in the pink bollworm has recently been reported. The Bt in these short duration cultivars is expected to control the other bollworms while a short duration genotype is essential to escape the pink bollworm. These measures should be accompanied by timely sowing, harvesting and terminating the crop while monitoring moth activity using pheromone traps with assured quality of lures, using recommended insecticidal interventions as moths cross ETL. Implemented as an area wide program especially in Central and South India it would hold the key to successful cotton cultivation in the next few years. Trials for other methods of pheromone use are still nascent and need well planned, unbiased experimentation in multi-location trials. Detailed strategies for the management of pink bollworm have been enlisted by Kranthi K.R. at http://www.cicr.org.in/pdf/Kranthi_art/Pinkbollworm.pdf.

Examples of Pheromone Formulations: Nomate R is a slow release formulation of gossyplure and hexane contained in 1.5cm length of 200u hollow fibres sealed at one end. Nomate PBW attract and Kill contains a small amount of permethrin 0.004 kg ai/Ha added to the polybutene sticker Botax used to adhere fibres to leaves. DisruptR a slow release system of gossyplure consisting of 3 layer plastic dispenser with gossyplure concentrated in the central reservoir. PBRope L a high rate slow release system consisting of a wire based sealed polyethylene tube 8 inches filled with gossyplure. Gossyplure was used for PBW monitoring in India. It was popular as a monitoring tool in the 1990s. In fact, PBRope L tested then was found to be economically non-viable. With newer and inexpensive methods for the production of synthetic gossyplure, pheromones are being revisited as pest management tools. SPLAT (Specialised Pheromone & Lure Application Technology), a new technology, is a proprietary base matrix formulation of biologically inert materials used to control the release of semio-chemicals and/or odours with or without pesticides. SPLAT facilitates and automates the dispensing of semio-chemicals and attractants; by simplifying the delivery of these chemicals in the field. Pheromones thus formulated can be applied through multiple methods as these formulations are available in a wide range of viscosity. SPLAT facilitates mechanisation of application. The amorphous and flowable quality of this formulation allows for an easy transition from small scale manual applications to large-scale mechanical applications. These formulations demonstrate rain fastness on vegetation being effective upto six months. It is being demonstrated for pink bollworm management on Bt cotton in India.

Stake holders need to understand and take aggressive, simple steps to mitigate pink bollworm damage in Bt cotton in India to prevent the collapse of the cotton sector as larvae not only affect quantity but also the quality of the fibre.

(The views expressed in this column are of the author and not that of Cotton Association of India)

Photographs courtesy Dr Vivek Shah and Dr Rachna Pande, Scientists (ICAR-CICR, Nagpur