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Cotton Exchange Building, 2nd Floor, Cotton Green, Mumbai - 400 033
Telephone: 8657442944/45/46/47/48 Email: cai@caionline.in
www.caionline.in

Pheromone Technology for Checkmating Pink Bollworm

Dr. K. Rameash is a Principal Scientist in ICAR-Central Institute for Cotton Research, Regional Station, Coimbatore. He has 18 years of research experience in agricultural entomology. His areas of work include biorational pest management, insecticide resistance management, nanotechnology and geographic information system in pest modelling.

EXPERT's Column

Dr. K. Rameash
Principal Scientist (Agricultural Entomology)
ICAR - Central Institute for Cotton Research, Regional Station, Coimbatore

The cryptic behaviour and lifecycle of pink bollworm (PBW) render it less amenable for the regular pest management practices employing insecticides and biocontrol agents. The larvae bore into cotton bolls immediately after hatching, remain inside by feeding on seeds and pupate under the soil surface, thus offering a very narrow window of control opportunity by the conventional strategies.

Alternative tools like behaviour-modifying chemicals or semiochemicals provide a pragmatic approach in managing the internal feeders and cryptic pests. The semiochemicals are naturally produced substances that mediate interactions between organisms. They are considered safe and environmentally friendly because they are natural, volatile and dissipate without leaving any unwanted residues.

Pheromone is one of the subtypes of semiochemicals, produced by an organism, affecting the behaviour of other individuals of its same species. Pheromones are released in very minute quality and provoke a specific reaction in the receiver, and based on the functions they are classified into aggregation pheromones, sex pheromones, alarm pheromones, oviposition-deterrent pheromones, etc. Structurally, pheromones are known to be the long-chain unsaturated esters, alcohols or aldehydes. Since the identification and characterisation of the first sex pheromone of silkworm moth in 1959, more than 600 species of lepidopteran pheromones have been identified and several molecules have been mass-produced through synthetic routes for commercial applications.

Their main features, i.e., species-specificity; non-toxicity to mammals and other beneficial organisms; compatibility with other pest management strategies; efficacy in minute amounts and rapid degradation in the environment make them a promising tool in pest

Flower damage -- rosetted sysmptom due to pink boll worm attack.

Open boll damage due to pink bollworm

monitoring and management of key pests on economically important crops. The international market for the insect pheromones is valued at USD 2.4 billion in 2019 and is anticipated to reach USD 5.7 billion by 2025.

Sex pheromones are the widely used ones and they account for the largest market share of around 82% of the total agricultural pheromone. These sex-attractant substances are generally produced in a minuscule amount by females and elicit drastic behavioural and physiological responses in conspecific mates over a long distance.

The sex pheromone of PBW, gossyplure, was identified during 1973 and was characterised as a mixture of Z, Z- and Z, E- isomers of 7,11-hexadecadienyl acetate. The female moth of PBW releases gossyplure at about 0.2 nanograms per minute for attracting its male counterpart during the process of signalling. Since its identification and biosynthesis, gossyplure has become an imperative tool in the management of PBW on cotton crop and has successfully been employed in the pest population monitoring, mass trapping and mating disruption.

Inter locular damage due to pink boll worm.

Monitoring Pest Populations

The most widespread and successful applications of sex pheromones are the detection and monitoring of key insect pests in major crops. Traps baited with pheromone lure can detect the presence and infestation of a pest at an early stage. Trapping data recorded over a wider area provide information on the migration and dispersal of the target pest and also help to detect the entry and progress of an invasive pest. One of the major applications of the pheromone trap data is the fixation of economic threshold levels (ETL) of a pest damage and to decide on the timing and selection of appropriate control strategies.

In cotton crop, sex pheromone lures play the main role in the monitoring of important lepidopterous pests like PBW (Pectinophora gossypiella); American bollworm (Helicoverpa armigera); leafworm (Spodoptera litura); spotted and spiny bollworms (Earias sp.). Particularly in the case of PBW, the damage symptoms and life stages of the pest are not noticeable during initial periods of infestation and hence, the decision of insecticidal spray is arrived at using the male catches in the traps. If the PBW male moth catches exceed eight per pheromone trap for three consecutive days, it is considered as having crossed the ETL and an insecticidal spray is recommended.

In addition to population monitoring, the trap catch data recorded over a crop season provide insights into the life cycle, seasonal dynamics and other vital parameters on the biology and

Pink bollworm larva

Pink bollworm pupa

ecology of the insect pest. The peak incidence of PBW is known to occur in cotton crop after three weeks of the first peak pheromone trap catch. With the supplementary corroboration of geographical and weather data, prediction and simulation modelling of pest damage could be projected.

Using an extensive data set of PBW moth trap catches and temperatures across the cotton-growing states of India, the ICAR- Central Institute for Cotton Research has come out with a degree day-based model to predict the phenology of this dreaded pest. Based on the model, a total of seven generations of PBW are determined in a cropping season, the length of which varied between 35 and 73 days in relation to temperature.

The model identifies the third generation as the crucial point of intervention for management actions, as the PBW population reaches its peak during that time. Further, the study also provides essential information for developing PBW strategies under changing climate scenarios.

Since the reappearance of PBW in Bt cotton, the ICAR- CICR is closely monitoring the pest status in major cotton-growing states viz., Haryana, Maharashtra, Gujarat, Madhya Pradesh, Andhra Pradesh, Telangana, Karnataka, and Tamil Nadu. Under the network project on Insecticide Resistance Management (IRM): Dissemination of Pink bollworm management strategies, sponsored by the National Food Security Mission: Commercial Crops, a total of 2520 pheromone traps have been installed in 105 identified villages across 21 cotton growing districts of the North, Central and South zones. Weekly trap catches and corresponding field damages by PBW are being recorded by trained personnel since 2018 at all the locations. Based on the observations, pest forewarning and suitable control measures are disseminated through various channels like mass media and direct voice/text messages to cotton growers across the zones.

A total of 1050 farmers were also adopted in the identified villages and critical inputs like insecticides, botanicals and biocontrol agents are supplied free of cost for the timely management of PBW. By this effective monitoring of PBW using pheromone traps and timely intervention through integrated pest management approaches, a reduction of 39.3% in the volume of pesticide usage was noticed among the adopted farmers. Periodical field demonstrations, kisan melas and campaigns are being conducted to popularise the importance of pest monitoring and timely management of PBW in cotton across the country.

The efficacy of pheromone trap monitoring is influenced by factors like trap design and its placement in the field. Pheromone trap placement (height and position) has to be optimised for a better result and it is advisable to relate the height of the trap to the height of the vegetation and make adjustments as the crop grows.

Further, the data collected from a single trap at any location are always less reliable than data that are the average of more than one trap at the given area. The ICAR-CICR recommends placing five pheromone traps per hectare for monitoring purpose and the height of traps has to be maintained at 30 cm above the crop canopy for a better trap catch.

Mass Trapping by Pheromones

Pheromone traps for monitoring purpose are typically used at low densities, and the trapping is known to cause no significant reduction in the population of a pest or its damage levels. The concept of mass trapping using pheromone compounds differs in these two aspects. Placing a high density of traps in the crop to be protected and achieving a measure of control through the removal of an adequately high proportion of individuals from the population are the key principles in mass trapping. A large number of pheromone baited traps are used in the field to capture males of the newly emerged moths to reduce the number of adults for mating; suppress the population and delay the build-up of the subsequent generation in mass trapping technique.

In the case of PBW, installation of a minimum of 20 traps per hectare are recommended for mass trapping and to gain the full benefit, it is advisable to install the traps two weeks before first flowering as it reduces the chance of establishment of first-generation larvae in the flowers. Pheromone septa need to be changed at regular time intervals and the traps should be maintained till the last picking of cotton for a better result.

Several field studies have been conducted at the state Agricultural Universities of Karnataka, Andhra Pradesh, Gujarat and Tamil Nadu for optimising the number of traps in the mass trapping system. In a recent experiment conducted at Gujarat, installation of 40 pheromone traps/ha, placed one week before flowering, positioned equidistantly at 30 cm above crop canopy, and changing the lure at one-month interval was found to be effective and economical for the management of PBW.

Researchers are constantly improvising and modifying the mass trapping system. An improved method, “attract and kill technique”, combining the use of pheromone as an attractant and an insecticide as a toxicant to kill the trapped insects was found to be more effective in mass trapping. A considerable improvement in the control of PBW is noticed when gossyplure traps were combined with insecticides like permethrin.

Pheromone trap

Mass trapping with pheromone compounds has few inherent limitations. The process of installation, regular checking, replacement of pheromone seta, adjustment of trap height at regular intervals are laborious and requires trained personnel. In lepidopterous pests like PBW, the sex pheromone entraps only the male moths while females are left unaffected. A male moth can fertilise more than one female, and as a result, a very high proportion of males would have to be removed from the population to reduce the mating and egg-laying by female moths significantly. The influx of new insects from an adjacent area may hamper the effectiveness of mass trapping. Hence, to ensure success, this technique needs to be adopted over a wider area with community-level participation.

Mating Disruption Using Pheromone Compounds

The mating disruption technology works on the principle that the entire crop field is saturated with sex pheromone to prevent male moths from locating females and thereby preventing the reproduction of target insects. The insect searching for a potential mate becomes confused in the treated field because it cannot distinguish between the pheromone source and the potential sex partner.

The first large-scale field testing of mating disruption was conducted with the PBW on cotton in the Coachella Valley of Southern California with the hollow-fibre formulation of gossyplure and the product became the first pheromone formulation to be registered with the U.S. Environmental Protection Agency during 1978. The success of the mating disruption in cotton crop with sex pheromone led to the development of similar systems against key pests like codling moth on pome fruit, the oriental fruit moth on peaches, tomato pinworm on vegetables and leafroller on grapevine.

Several dispensation systems for the mating disruption of PBW were developed worldwide (No Mate-PBW®, PB-ROPE®, Selibate®, Disrupt® etc.) and their efficacy was successfully demonstrated in different cotton-growing areas of the U.S., Mexico, Israel, Pakistan and Egypt. In India, field studies were conducted with the PB-Rope system in the major cotton-growing states Karnataka, Andhra Pradesh, Gujarat and Rajasthan.

Commercially, the use of PB Rope L® is approved by the Central Insecticides Board & Registration Committee for the mating disruption of PBW on cotton with a recommended dose of 395 dispensers/ha in a minimum treatment area of 25 hectares. The PB Rope L® contains 140 mg of gossyplure/dispenser and it is tied around the main stem of cotton above the first or second pair of true leaves at the first pin square stage and retained till the last picking for season-long control. Another promising formulation in the mating disruption of cotton PBW is the SPLAT (Specialised Pheromone and Lure Application Technology) wherein the gossyplure is formulated with wax and applied as dollops onto the base of leaf petiole of the top shoot of cotton plant.

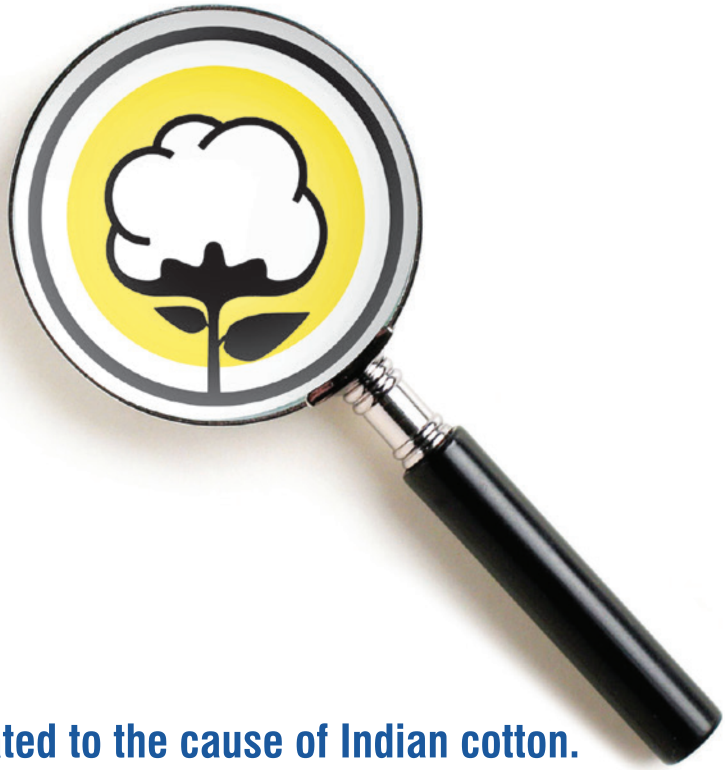
The success of a mating disruption technology is strongly associated with the population density of insect pests. Generally, high-density insect populations are tougher to control than less dense infestations. Mating disruption coupled with others strategies like male-sterile PBW releases; transgenic Bt cotton; need-based insecticide spray was proved to be successful in high-density population scenarios. The immigration of mated females from nearby fields remains the main drawback of the technology. Area-wide approach and timely application of pheromone compound have to be ensured to reduce the possibility of immigration and to achieve satisfactory control of PBW in the mating disruption technology. A concentrated effort by the researchers, extension functionaries and farmer cooperative societies remains a prerequisite in implementing the mating disruption technology as an area-wide approach.

Conclusion

Undoubtedly, pheromones remain an essential component in any pest management program due to their unmatched compatibility with the other management options. They are being widely used in many crops across the globe for several decades and so far, there is no documented evidence to suggest that agricultural use of synthetic pheromones is harmful to humans or any other non-target organisms. The desirable qualities viz., specificity (targeting only the intended pest); sensitivity (effective at minuscule quantity); simplicity (easy to install infield) and safety (non-toxic to mammals and natural enemies) renders the pheromones application an undisputed strategy in the monitoring and management of key insect pests in a high-value crop like cotton.

Few identified limitations of pheromone technology could be circumvented by research and innovations on improving the trap design and dispensation system and by creating awareness among the farmers and other stakeholders for a community level, area-wide adoption.

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



Revision in Testing Charges at CAI Laboratories

The following are the charges for cotton testing in the laboratories of the Cotton Association of India with effect from 1st October 2020.

Particulars	Per Sample Testing Fees in Rs.		
	Testing Fees	GST	Total
HVI Test	145	26	171
Micronaire Test	85	15	100
Colour Grade on HVI	85	15	100
Gravimetric Trash Test on HVI	85	15	100
Moisture	85	15	100
Grading (Manual Classing)	235	42	277

VOLUME BASED DISCOUNTS

Particulars	Per Sample Testing Fees in Rs.		
	Testing Fees	GST	Total
For 250 samples and above but less than 500 samples	140	25	165
For 500 samples and above but less than 750 samples	135	24	159
For 750 samples and above but less than 1000 samples	130	23	153
For 1000 samples and above but less than 2000 samples	125	23	148
For 2000 samples and above but less than 5000 samples	120	22	142
For 5000 samples and above but less than 10,000 samples	115	21	136
For 10,000 samples and above	100	18	118

The fees under the above volume based discount scheme is payable within 15 days from the receipt of the invoices to be raised on monthly basis.

We would also like to inform that the parties can avail the benefit of testing of cotton at multiple laboratories of the Associations against the CAI Credits made by them.

We earnestly request you to avail the facility of testing at the Association's laboratories.

COTTON ASSOCIATION OF INDIA
Established 1921
ISO 9001:2015

Cotton Association of India
Cotton Exchange Building, 2nd Floor, Opposite Cotton Green Railway Station,
Cotton Green (East), Mumbai - 400 033.
Tel.: +91 8657442944/45/46/47/48 • E-mail: cai@caionline.in • www.caionline.in

UPCOUNTRY SPOT RATES

(Rs./Qtl)

Standard Descriptions with Basic Grade & Staple in Millimetres based on Upper Half Mean Length [By law 66 (A) (a) (4)]								Spot Rate (Upcountry) 2020-21 Crop August 2021					
Sr. No.	Growth	Grade Standard	Grade	Staple	Micronaire	Gravimetric Trash	Strength /GPT	16th	17th	18th	19th	20th	21st
1	P/H/R	ICS-101	Fine	Below 22mm	5.0 – 7.0	4%	15	12035 (42800)	12035 (42800)	12035 (42800)	12035 (42800)	11979 (42600)	11923 (42400)
2	P/H/R (SG)	ICS-201	Fine	Below 22mm	5.0 – 7.0	4.5%	15	12232 (43500)	12232 (43500)	12232 (43500)	12232 (43500)	12176 (43300)	12120 (43100)
3	GUJ	ICS-102	Fine	22mm	4.0 – 6.0	13%	20	10039 (35700)	10039 (35700)	10039 (35700)	10039 (35700)	9926 (35300)	9898 (35200)
4	KAR	ICS-103	Fine	23mm	4.0 – 5.5	4.5%	21	10573 (37600)	10573 (37600)	10573 (37600)	10573 (37600)	10489 (37300)	10432 (37100)
5	M/M (P)	ICS-104	Fine	24mm	4.0 – 5.5	4%	23	11810 (42000)	11810 (42000)	11810 (42000)	11810 (42000)	11810 (42000)	11754 (41800)
6	P/H/R (U) (SG)	ICS-202	Fine	27mm	3.5 – 4.9	4.5%	26	14060 (50000)	14060 (50000)	14060 (50000)	14060 (50000)	13976 (49700)	13919 (49500)
7	M/M(P)/ SA/TL	ICS-105	Fine	26mm	3.0 – 3.4	4%	25	12513 (44500)	12513 (44500)	12513 (44500)	12513 (44500)	12429 (44200)	12373 (44000)
8	P/H/R(U)	ICS-105	Fine	27mm	3.5 – 4.9	4%	26	14285 (50800)	14257 (50700)	14285 (50800)	14313 (50900)	14229 (50600)	14144 (50300)
9	M/M(P)/ SA/TL/G	ICS-105	Fine	27mm	3.0 – 3.4	4%	25	13076 (46500)	13076 (46500)	13076 (46500)	13076 (46500)	12991 (46200)	12935 (46000)
10	M/M(P)/ SA/TL	ICS-105	Fine	27mm	3.5 – 4.9	3.5%	26	14116 (50200)	14116 (50200)	14116 (50200)	14144 (50300)	14060 (50000)	13976 (49700)
11	P/H/R(U)	ICS-105	Fine	28mm	3.5 – 4.9	4%	27	14510 (51600)	14510 (51600)	14538 (51700)	14566 (51800)	14482 (51500)	14397 (51200)
12	M/M(P)	ICS-105	Fine	28mm	3.7 – 4.5	3.5%	27	14875 (52900)	14875 (52900)	14904 (53000)	14904 (53000)	14904 (53000)	14847 (52800)
13	SA/TL/K	ICS-105	Fine	28mm	3.7 – 4.5	3.5%	27	14904 (53000)	14904 (53000)	14932 (53100)	14932 (53100)	14932 (53100)	14875 (52900)
14	GUJ	ICS-105	Fine	28mm	3.7 – 4.5	3%	27	15213 (54100)	15213 (54100)	15269 (54300)	15325 (54500)	15241 (54200)	15185 (54000)
15	R(L)	ICS-105	Fine	29mm	3.7 – 4.5	3.5%	28	14904 (53000)	14904 (53000)	14960 (53200)	14960 (53200)	14875 (52900)	14791 (52600)
16	M/M(P)	ICS-105	Fine	29mm	3.7 – 4.5	3.5%	28	15382 (54700)	15382 (54700)	15410 (54800)	15466 (55000)	15382 (54700)	15325 (54500)
17	SA/TL/K	ICS-105	Fine	29mm	3.7 – 4.5	3%	28	15410 (54800)	15410 (54800)	15438 (54900)	15494 (55100)	15410 (54800)	15353 (54600)
18	GUJ	ICS-105	Fine	29mm	3.7 – 4.5	3%	28	15747 (56000)	15832 (56300)	15888 (56500)	15916 (56600)	15803 (56200)	15747 (56000)
19	M/M(P)	ICS-105	Fine	30mm	3.7 – 4.5	3.5%	29	15916 (56600)	15916 (56600)	15916 (56600)	15916 (56600)	15832 (56300)	15747 (56000)
20	SA/TL/K/O	ICS-105	Fine	30mm	3.7 – 4.5	3%	29	15972 (56800)	15972 (56800)	15972 (56800)	15972 (56800)	15888 (56500)	15803 (56200)
21	M/M(P)	ICS-105	Fine	31mm	3.7 – 4.5	3%	30	16197 (57600)	16197 (57600)	16197 (57600)	16197 (57600)	16085 (57200)	15972 (56800)
22	SA/TL/ K / TN/O	ICS-105	Fine	31mm	3.7 – 4.5	3%	30	16253 (57800)	16253 (57800)	16253 (57800)	16253 (57800)	16141 (57400)	16028 (57000)
23	SA/TL/K/ TN/O	ICS-106	Fine	32mm	3.5 – 4.2	3%	31	16506 (58700)	16506 (58700)	16506 (58700)	16506 (58700)	16366 (58200)	16281 (57900)
24	M/M(P)	ICS-107	Fine	34mm	2.8 - 3.7	4%	33	26152 (93000)	26011 (92500)	26011 (92500)	26011 (92500)	25870 (92000)	25870 (92000)
25	K/TN	ICS-107	Fine	34mm	2.8 - 3.7	3.5%	34	27276 (97000)	26995 (96000)	27136 (96500)	27136 (96500)	26995 (96000)	26995 (96000)
26	M/M(P)	ICS-107	Fine	35mm	2.8 - 3.7	4%	35	26995 (96000)	26995 (96000)	26995 (96000)	27136 (96500)	26995 (96000)	26995 (96000)
27	K/TN	ICS-107	Fine	35mm	2.8 - 3.7	3.5%	35	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)	N.A. (N.A.)

(Note: Figures in bracket indicate prices in Rs./Candy)