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Role of different types of pheromone in IPM

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Introduction

Pheromones are a naturally occurring chemical compounds found in all insects, animals, and humans. The term 'pheromone' was introduced by Karlson and Luscher and it derives from the Greek words 'pherein' (to carry) and 'hormon' (to excite). These are referred to as 'ecto-hormones' as they are chemical messengers that are emitted into the environment from the body where they can then activate specific physiological or behavioral responses in other individuals of the same species. Insect pheromones are volatile organic molecules of low molecular weight that elicit a behavioral response from individuals of the same species and can be used to communicate between members of the same or the opposite sex. Pheromones are generally produced by specialized exocrine glands associated with the cuticle. Pheromones are natural scents which play an important role in sexual communication. These Pheromone aromas convey signals relating to mood, status, drive and health to the subconscious awareness of the opposite sex.

This philosophy holds well in the animal world, pheromones are consciously detected over considerable distances and serve at times in place of real communication. They help insects to mark territory, recognize mates, and signal sexual interest.

Role of Pheromones in integrated pest management

There are three main uses of pheromones in the integrated pest management. The most important application is in monitoring a population of insects to determine if they are present or absent in an area or to determine if enough insects are present to warrant a costly treatment. This monitoring function is the keystone of integrated pest management. Monitoring is used extensively in urban pest control of cockroaches, in the management of stored grain pests in warehouses or distribution centers, and to track the nationwide spread of certain major pests such as the gypsy moth. A second major use of pheromones is to mass trap of insects to remove large numbers of

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insects from the breeding and feeding population. Massive reductions in the population density of pests ultimately help to protect resources such as food or fiber for human use. A third major application of pheromones is in the disruption of mating in populations of insects. This has been most effectively used with agriculturally important moth pests. In this scenario, synthetic pheromone is dispersed into crop fields and the false odour plumes attract males away from females that are waiting to mate. This causes a reduction of mating, and thus reduces the population density of the pests

Classification of pheromones

Based on the responses elicited, pheromones can be classified into two group:

- **Primer pheromones:** They trigger off a chain of physiological changes in the recipient without any immediate change on the behavior. They act through gustatory (taste) sensilla and are not found in Lepidopteron insects.
- **Releaser pheromones:** These pheromones produce an immediate change in the behavior of the recipient. These act through olfactory (smell) sensilla and directly act on the central nervous system of the recipient and modify their behavior. These are further subdivided into various types out of which only following three are known to occur in Lepidopteron insects.
- **Pheromone producing glands:** The glands that produce pheromones are ectodermal in origin; they open and release their products outside the body. They are therefore called exocrine glands as distinct from the endocrine glands which release their products (hormones) inside the body. These glands can be present on any part of the body i.e. head, thorax, abdomen, legs or wings-depending on the species.

Types of Insect Pheromones

Sex Pheromones: Sex pheromones act as a signal to attract potential mates over long distances (e.g. moths). Sensitive chemoreceptive sensilla in insects facilitate the detection of very low concentrations of sex pheromones in the environment. Release of sex pheromones may be governed by factors such as time of day, weather, and the availability of host plants. Furthermore, both the immature and adult stages of insects can sequester chemicals from host plants and use them as precursors for sex pheromones. Different sex pheromones is mentioned in table.1

Alarm Pheromones: Some insects (e.g. aphids) release alarm pheromones in response to attack by natural enemies. Alarm pheromones serve as a trigger for dispersal and avoidance behavior among the conspecifics.

However, some social insects may respond aggressively to alarm pheromones (e.g. bees in genus *Apis* and leaf-cutting ants).

Different alarm pheromones is mentioned in **table. 1**

Sex pheromone		Alarm pheromone	
Insect	**compound**	**Insect**	**compound**
Honeybee	9-Keto-2-decenoic acid	Honey bee	Heptan-2-one
Cabbage looper	cis-7-Dodecen-1-01	Claviger	Tridecan-2-one
Fall army worm	cis-9-Tetradecen-l -ol	Cocktail ants	2-tram-Hexan-1-a1
Silk worm moth	trans-10-cis-12-Hexadecadien-l –ol	Nylander	2-Methyl-2-hepten-6-one
Male butterfly	Cetyl acetate	Snouted termite	or-Pinene
Pink bollworm	1 O-Propyl-tram-5,9-tridecadienyl acetate	Leaf cutter ants	Citral

Aggregation Pheromones: These can be defined as intraspecific signals that facilitate group formation and mating at a food source. (For example, aggregation pheromones released by some species of bark beetles (Scolytidae: Coleoptera) result in the recruitment of other individuals of either sex to the feeding site.

Anti-Aggregation Pheromones: These compounds result in the dispersal of individuals (both sexes) and help maintain optimum spacing in a resource-limited environment

Oviposition-Deterring or Epideictic Pheromones: These compounds help females of certain insect species avoid egg deposition on hosts that have already been utilized by conspecifics and thus reduce intraspecific competition. Females of numerous species of fruit flies (Diptera: Tephritidae), e.g. Mediterranean fruit fly, *Ceratitis capitata Wiedemann*, deposit an oviposition-deterring fruit-marking pheromone during ovipositor dragging after egglaying. Similarly pepper weevil, *Anthonomus eugenii* Cano (Coleoptera: Curculionidae) females deposit an oviposition plug that deters egg-laying.

Trail Pheromones: Social insects (e.g. ants and termites) use trail pheromones to mark feeding or nest sites to guide members of their colony

Mode of action of Pheromones in integrated Pest Management

Detection and Monitoring: The principle use of insect pheromones is to attract insects to traps for detection and determination of temporal distribution. In most instances, the

males are responders to female-produced pheromones. Trap baits, therefore, are designed to closely reproduce the ratio of chemical components and emission rate of calling females. Trap baits of many designs have been tested over the years. 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. 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. Yellow sticky traps has shown in figure.1

Mass trapping: In mass trapping a very high proportion of the pest is caught before mating or oviposition to reduce the pest population. For Lepidopteron insects, it is essential that males are trapped before mating and it is most likely to succeed with insects that mate only once. Factors that make mass trapping non-viable on large scale are Lack of attraction of females by the attractant source, Lack of highly efficient traps, Problem of high insect populations and trap saturation, Need for a high density of traps per unit of surface area which in turn renders the technique too costly.

Lure and kill technique: Also referred as "attracticide", "attract and kill", "attraction-annihilation", or "male annihilation" it is a modification of mass trapping in which the moth is lured by a synthetic pheromone it is not only caught in the trap, but also subjected to tactics combine pheromones with insecticides. More recently, lure and kill has been reported to work against codling moth, *Cydia pomonella* and commercial product "Sirene" Novartis is now registered in Switzerland.

Lure and infect technique: A more elegant development of this general approach is called auto-dissemination and combines insect pathogens with pheromones. The aim of this tactics is not to kill the insects' right way, but rather to use them as vectors of the disease into the wider population. Different pathogens could be used, with slightly different pathways from virus e.g. baculo-virus or grannulosis virus, fungus e.g. *Zoopthora radicans*, or a bacterium e.g. *Serratia entomophilla* or even entomopathogenic nematodes. This approach has been explored with nucleo polyhydrosis virus against Tobacco budworm, *Spodoptera littura* and a granulosis virus against codling moth, *Cydia pomonella*.

Auto-confusion: It is a pest management strategy that differs from the traditional mating disruption, in that it uses males as mobile dispensers. The relevance of this technique lies in that limited quantities of pheromone and a small number of dispensers per hectare (25-30/ha) are needed, resulting in important benefits for farmers in terms of deployment time and for the environment since less waste material is produced.

Methods of pheromone application: Different methods have been devised for the application of pheromones in the field

- **Micro-encapsulation method**: The pheromone is enclosed in small (Ca.50 µm) plastic capsules which are dispensed with conventional spray equipment's to provide their uniform distribution.
- **Hollow fiber method**: Here the pheromone is kept in hollow plastic fibers (capillaries) which are cut in small pieces and scattered by the help of an aircraft. The fibers may also be fashioned into hoops (coils) and tied to upper part of stems.
- **Pheromone baited traps**: These are specially devised structures of various shapes and sizes which could be suspended from trees or elevated objects. Many types of traps are now available commercially of which the Pherocon R, Sector XC-26 and Sector 1 traps are more popular.

Pheromone dispensers: These are the latest devices that can release the pheromone at precisely calculated rates. A commonly used dispenser has been patented as Pherocon controlled release dispenser. It is made up of the plastic laminates, the middle layer acting as a reservoir in which the pheromone (or any lure) is embedded and the outer layer as a barrier that regulate the rate of pheromone release. These dispensers come in shapes of square (0.5- 2.5 cm) ribbons and flakes. Flakes are scattered (with a sticker to stick the particles to the crops foliage) by an aircraft over dense vegetation (forests, orchards) while squares and ribbons can be placed manually. Some 10000-20000 sex pheromone flakes can mask the odour of a "calling" female in one

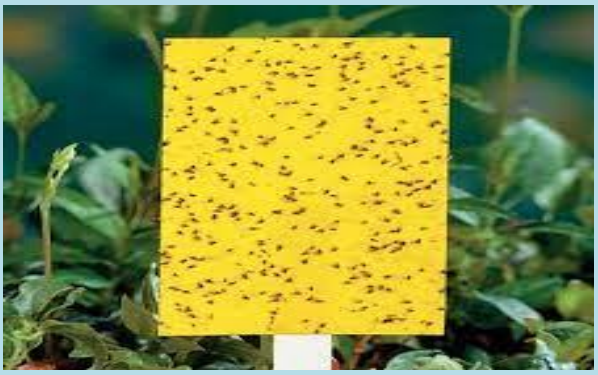

Fig.1

Fig.2

acre area thereby causing mating disruption. In figure.2 mating disruption dispenser is installed in apple orchard for codling moth.

Conclusion

India has been enormously successful in increasing its agricultural production in an effort to attain self-sufficiency. This has been largely achieved through new technologies in agriculture. Pheromones and other behavior-modifying semio-chemicals are now an integral part of numerous pest management programmes and are expected to play an important role in high-tech crop protection of the future. These will help provide a sustainable and environmentally friendly replacement to the broad-spectrum insecticides, either as monitoring or management tools of critical IPM programmes. Potentially useful interactions occur not only within one sensory modality such as olfaction, but can derive from different sensory modalities such as vision and olfaction. Other promising areas of research include the use of multiple pheromones to monitor several pests simultaneously, use of pheromones for behavioral manipulation of natural enemies, understanding the mechanisms underlying mating disruption and other pheromone-based control approaches, and the use of multiple pheromones for controlling several pests simultaneously in a mating disruption scenario. The ultimate challenge will be to increase the adoption of pheromone-based pest management technologies by making them cost-effective, but without sacrificing efficacy.