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Pheromones in Insect Pest Management

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Insects that are nocturnal (night flying moths), soil dwelling insects and social insects living in enclosed nests make great use of odour signals. It has become clear that externally secreted chemicals are involved in attraction and control of insect development. In addition, the interaction between plant species and insects are involves a variety of chemical substances. The relationship between plant chemical stimuli and insect response is a form of chemical communication between these organisms. Such chemicals, which are involved in communication, are known as semiochemicals. These are further divided into subdivided into allelochemicals and pheromones.

Allelochemicals: These are involved in interspecific communication and defined as non-nutrient substances originating from an organism (plant or animal), which affect the behaviour, physiological condition or ecological welfare of organisms of another species. These are classified into different categories as follows:

1. **Allomones:** These chemical signals give advantage to the emitter (e.g., defensive secretions).
2. **Kairomones:** are those that give an advantage to the receiver (e.g. secretions that can be detected by a parasite or predator).
3. **Synomones:** These chemical signals give advantages to both sender and receiver.
4. **Antimony:** are those in which neither benefit.

Pheromone: In 1959, German chemist, Adolf Butenandt, who identifies and isolates first insect pheromone from silk worm and the substance was a kind of alcohol that Butenandt christened bombykol, after the moths name, Bombyx mori. German Biochemist, Peter Karlson and Swiss Entomologist, Martin Lüscher (1959), who had been engaged in- research on the chemical control of caste development in termites, proposed the term 'pheromone' (a word with Greek roots meaning 'carrier of excitation') to describe a chemical that an animal secretes or excretes that release a specific reaction for example, a definite behaviour or developmental process in a member of the same species. These pheromones are divided into releasers, which induce an immediate behavioural change and primers, which initiate changes in development, such as sexual maturation, and so do not result in immediate behavioural changes. These are further classified as follows:

1. **Sex pheromone:** A substance generally produced by the female to attract male for mating.
2. **Aggregation Pheromone:** a substance produced by one or both sexes and bringing both sexes together for feeding and reproduction.
3. **Alarm pheromone:** a substance produced by an insect to repel and disperse other insects in the area. e.g., the secretions produced by worker ants when they encounter a threatening situation.

4. **Parapheromone:** when a chemical not found in an animal has a pheromone-like action, e.g synthetic compound trimedlure, which is the best-known attractant for the male Mediterranean fruit fly, *Ceratitis capitata*.

Among the different types of pheromones, sex pheromones are gained importance in the pest management programme. Pheromones have the ability to involve in the metamorphosis, behavioural changes and sexual maturation. These natural properties of the pheromones have attracted the attention of several entomologists those who involved in the pest management service to exploit the pheromones in insect pest control. Pheromone chemistry ranges from the blends of aliphatic alcohols, aldehydes, esters and epoxides exploited by lepidopterous insects to alkenoic acids and aldehydes, branched alkanones, esters, monoterpene alcohols and aldehydes to a furanone employed by beetles.

Pheromones in pest management: Pheromones are crucial in the insect life cycle and are therefore excellent targets to interfere with to obtain pest control. One of the first attempts at controlling insects by pheromones was made against the gypsy moth, Porthetria dispar. Attempts were made to control the gypsy moth by using traps baited with virgin females. Later crude extracts of female abdominal tips were used in monitoring traps. The chemical compound was an alcohol named, gyptol. Subsequently disparture isolated and synthesized. Over the last 40 years, scientists have identified pheromones from over 1,500 different species of insects. Some of the important and frequently used pheromones are given in table 1. Pheromones can be used in different techniques in the pest management programme as follows:

Monitoring: The use of sexual pheromones as lures in monitoring traps is now wide spread. Monitoring serves four functions: detection of outbreaks, establishment of emergence times of adult insects, distribution mapping and assessment of changes in abundance. Pheromone baited traps for monitoring pest populations provide a highly sensitive means of detecting the insect pests with many advantages over conventional methods such as light traps and scouting programmes. Pheromone monitoring systems can thus provide vital intelligence for the timing of insecticidal control measures. e.g., use of pheromone traps for cotton boll worm, tobacco caterpillar, pink boll worm etc.

Mass trapping: Population reduction by mass trapping becomes feasible with attractants that can outcompete sexual attractants. Most successful examples are those of the bark beetle trapping programmes. In these insects, communication involves both aggregation and sexual pheromones and so both males and females can be lured into traps. A powerful highly specific attractant should trap a sufficiently large number of target pest individuals to reduce its population below economic threshold level. A modification of mass trapping is the lure and kills technique where instead of being trapped; the responding insects are exposed to a pesticide.

Mating disruption: This technique depends on blocking the communication channel between male and female insects by flooding the medium with sexual pheromone. The exact way in which mating disruption is achieved may include masking of aerial trails by the persistent cloud of odour, the formation of false trails from dispensers that act as female of male mimics, greatly outnumbering the calling insects. The greatest success has been achieved for the control of pink bollworm, *Pectinophora gossypiella* by using controlled release formulations of its female sex pheromone a 1:1 mixture of (Z, E) and (Z, Z)-7, 11-hexadecadienyl acetate known as gossyplure.

Aggregation pheromone: These pheromones induce Aggregation of insects for protection, reproduction and feeding or combinations. This type of pheromones is mostly prevalent in coleopterans. e.g., Females of the bark beetle, *Dendroctonus frontalis* and males of phloem beetle, *Ips confusus*. These insect species produce a aggregation pheromone, frontalin (*Dendroctonus*) and ipsenol (*Ips*) for their aggregation, mating and feeding purposes.

Inhibition of oviposition: Anti-oviposition pheromones are known to occur in various Lepidoptera and Diptera. They are also known as epideitic pheromones, in reference to their effects of reducing intraspecific competition. eg female cabbage white butterflies add an anti-oviposition pheromone to the eggs during egg-laying and inhibits egg laying by conspecific females. In another example, females of the fruit fly (*Rhagoletis cerasi*) mark the fruit around the oviposition puncture and leaving the trial, which contains a pheromone. This host-marking pheromone deters other females of the same species from ovipositing on the same fruit. This type of pheromones can be used in the pest management programme in order to reduce the attack by the insect pests.

Alarm pheromones: Aphid species uses this type of pheromone to causes groups of aphids to stop feeding and disperse rapidly. The component of the pheromone is (E)-β farnesene. This type of pheromone has been used to mobilize feeding aphids and insecticide sprays and pathogens more easily target them. e.g., Glandular hairs on leaves of the wild potato released (E)-B- farnesene compound, which repels the aphid *Myzus persicae*.

Use of toxic baits: The use of pheromones in this type of toxic bait is very less though food attractants and parapheromones have been used extensively. e.g. Methyl eugenol, which is a component of many flower fragrances is strongly attractive to males of certain tephritid Diptera. The compound have been used in the bait impregnated with insecticides and has been successfully used in eradiation campaigns for the control of oriental fruit fly, *Bactrocera dorsalis*.

Stimulo-deterrent methods: In this technique, chemical substances may involve deterring insects from colonizing certain plants and at the same time, attracting them to other areas, hence the term 'stimulo-deterrent. e.g., strips of cotton planted early in the season and baited with grandlure, the synthetic pheromone of the boll weevil. Weevils are then killed with insecticide before they can spread to the commercial, which fruits later.

Bioelectric methods: The use of electrostatically charged powders as carriers for insecticides and biologically active chemicals, which adhere to the insect cuticle by electrostatic forces and can be used as slow-release substrates for pheromones. e.g., pest control can be achieved by attracting insect to bait with sex pheromones, where they pick up an inoculums of slow acting pesticides or pathogen, which they then pass on to mates during the mating process.

Formulations for pheromone: Since pheromones are volatile in nature, slow-release formulations have been developed so that an effective release maintained over several days after application. Such pheromone formulations are commercially available for several crop pests. Generally, the formulations used for monitoring are in the form of rubber septa, polyethylenevials or polyvinyl chloride dispenser, where as those for mating disruption purposes include plastic hollow fibres, plastic laminate flakes, polyethylene tube dispenser, bag dispensers etc. Some formulations are also available as emulsifiable concentrate or as polymeric aerosol. The microencapsulated formulation is used in aqueous suspension and can be sprayed by conventional applicators, but the fibre and flake formulations require an adhesive to ensure that they stick to foliage. Polyethylene tubes have to be applied by hand individually.

Advantages

Pheromones can be used in integrated control along with many other methods.

1. Pheromone monitoring traps are cheap to produce and transport and are highly selective.

2. Its compatibility with biological control and it is to be hoped that it will herald a new era in which the use of chemical pesticides will decline.
3. Pheromone monitoring traps are involved in detection, density estimation, forewarning of insect-pests and timing of pesticide application.
4. It is not leaving any toxic residues so these are environmentally safe.

Disadvantages

1. It is effective against a single pest or a closely related group of insects.
2. Pheromones are not providing immediate control of pests.
3. The chemical substances are not stable and photodegradable.
4. It has to be applied on an area wide basis in order to achieve desired results.
5. Lack of proper delivery system of pheromones in the field.

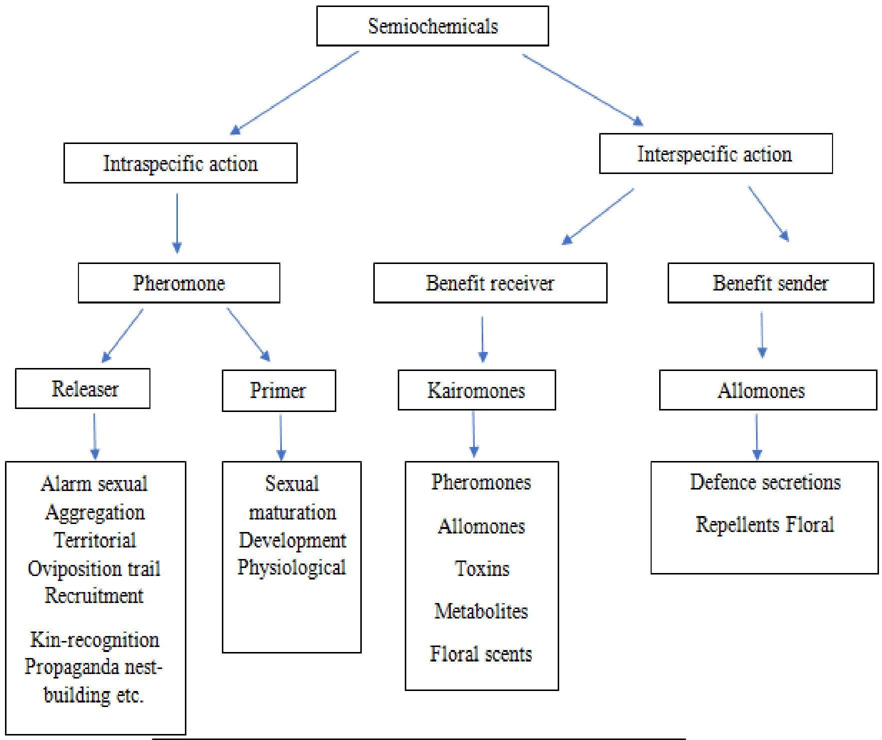

Fig.1 Categories of semiochemicals with examples (Reference: from Howse *et al*, 1998)

Table 1. Pheromones of some important insect pests

Sr. No.	Common name	Insect species	Pheromone
1	Gypsy moth	*Porthetria dispar*	10-acetoxy-cis-7-hexa- decnol (Gyptol)
2	Pink bollworm	*Pectinophora gossypiella*	(Z, E)-7, 11-hexadecadien-1-ol acetate and (Z, Z)-7-11-hexadecadien-1-ol acetate (1:1) (Gossyplure)
3	American bollworm	*Helicoverpa armigera*	(Z)-11-hexadecenal and (Z)-9-hexadecenal (97:3) (Helilure)
4	Tobacco caterpillar	*Spodoptera litura*	(Z, Z)-9, 11- tetradecadienyl acetate and (Z, Z)-9, 12- tetradecadienyl acetate (10:1) (Spodolure)
5	Rice stem borer	*Chilo suppressalis*	(Z)-9-hexadecenal and (Z) 13-ctadecenal
6	Yellow stem borer	*Scipophaga incertulas*	(Z)-11-hexadecenal and (Z)-9-hexadecenal (3:1)
7	Brinjal fruit and shoot borer	*Leucinodes orbonalis*	(E)-11-hexadecenyl acetate

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