Manipulation of Insect Behavior by Mating Disruption Technique

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ABSTRACT

Insect pest management has relied predominantly on conventional insecticides, but due to wide spread concern over potential hazards and development of resistance, alternative control methods have been developed. One such potential management tactic is the use of pheromones as mating disruption technique in pest management. The idea of dispersing sex pheromones inside a crop canopy to prevent insect pests from reproducing initiated in the early 1960s which contributed to the development of chemical ecology and continued to be well-known for a variety of reasons. Mating disruption is a technique that affects sexual behaviour of insect by saturating the surrounding environment by synthetic sex pheromones, where the ability of males to recognize the natural sex pheromone produced by females are disrupted so delaying the time for females to mate. This approach can be successful when mating disruption targets the key pest at low population densities. The combination of pheromone formulations with other management tactics can increase the efficacy of the formulation on the target pest, help to prevent the development of resistance to any one given management tactic and contribute for the management of more than one insect pest.

INTRODUCTION

Many species of insects communicate by using a variety of chemicals. Chemical signals that elicit a response from other members of the same species are called "pheromones". "Sex pheromones" attract one sex to the other so that mating can take place and are relatively common in the insect order Lepidoptera. Sex pheromones are a complex mixture of chemicals and each species has its own specific blend. In most cases it is the female moth that emits the sex pheromones and the male that follows the pheromone trail (or plume) to find the female. Mating disruption, a mechanistic approach, is a pest management technique which aims to disrupt chemical communication by insects and interrupt normal mating behaviour by dispensing synthetic sex pheromone, thereby affecting the organism's chance of reproduction.

How does it work?

Mating disruption technology uses synthetically produced chemicals in large amounts to confuse males and limit their ability to locate calling females; the blends, however, are often restricted to major components released by females. By introducing many sources of the sex pheromone into the ecosystem, the probability of the male finding the female is reduced, as is the likelihood of successful mating. As a result, mating is either delayed or prevented. If female moths do not mate, they cannot lay fertile eggs and, if their mating is delayed, they will lay fewer fertilized eggs in their lifetime. Consequently, the subsequent population is reduced, and fewer larvae are present to cause crop damage (Cardé *et al.* 1975).

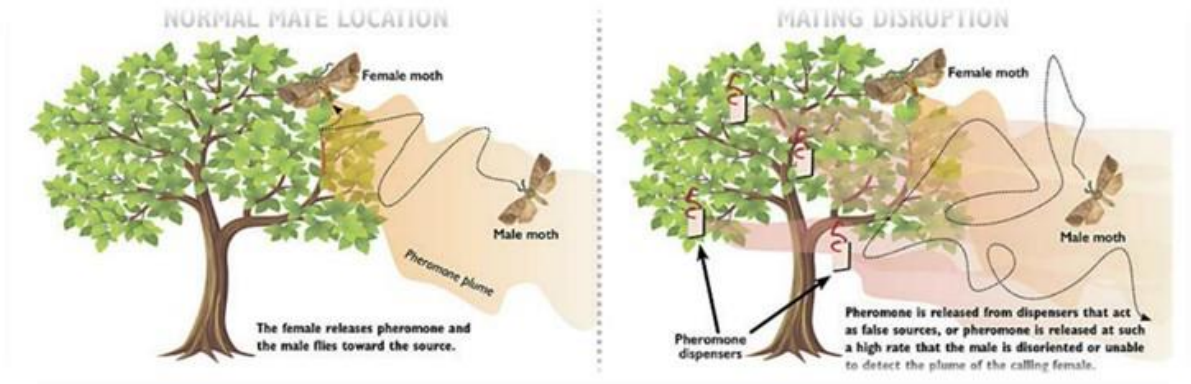

Fig 1: Working principle of mating disruption

Prerequisites:

a. Size and location of orchard: The success of mating disruption can be influenced by orchard size and isolation. In small orchards (less than 10 acres) or in larger ones near a source of the pest, mating disruption may not provide reliable control.

b. Pest levels: Mating disruption alone will normally not be adequate to reduce high pest populations to non-damaging levels. The first year, in which mating disruption is used, insecticidal control may be required to reduce pest populations to levels that can then be maintained by pheromones alone.

c. Non-target pests: The highly selective nature of mating disruption has a positive side as it is harmless for the predators and parasites will keep some of these pests below damaging levels.

d. Monitoring: More intensive monitoring will be needed in a mating disruption program. Because the target of mating

disruption is not killed by the treatment, its activity and density in the field must be followed to ensure adequate control (Brunner and Alan, 1993).

Mechanisms of mating disruption

It is possible that for a pest species more than one of these mechanisms could be operating at the same time to achieve control. The mechanisms are:

a. ***False trail following:*** If numerous sources of pheromone are placed in the orchard or field, male moths would spend time and energy following pheromone trails to false sources. If there were enough false sources, the chances of a male finding a calling female would be very low. The male moths may follow false pheromone trails until they reach concentrations that are too high and no longer attractive.

b. ***Camouflage/ Masking:*** This mechanism assumes the moth's sensory system is working normally. In this case, the background level of the pheromone is high and uniform enough to mask the odour trail from a calling female.

c. ***Neurophysiological effects / Desensitization: Adaptation*** occurs when sensory organs are exposed constantly to high and uniform levels of pheromone in the orchard, inhibiting their ability to detect the pheromone. Adapted sensory organs recover rapidly, in 2 to 3 seconds, when they are no longer exposed to the pheromone.

Habituation occurs when high concentrations of a pheromone inhibit the insect's ability to respond for several minutes or even a few hours. The effect is apparently on the nerve that fires in response to high concentrations but does not recover normally.

d. ***Sensory imbalance:*** If a single component of the pheromone, or an altered ratio of components, is released, males might not be able to detect or find the blend of pheromone released by females. If they continually receive signals that are out of balance with the one their sensory system is designed to pick up, their mate-seeking behavior might be inhibited (Gut *et al.* 2004).

Formulations of mating disruptors:

According to Miller and Gut (2015), mating disruption formulations have been engineered with the following criteria in mind, they are:

- ✓ Release of pheromone over an extended time
- ✓ Protection of the sensitive active ingredient from degradation
- ✓ Ease of application
- ✓ Affordability in the marketplace
- ✓ The extent to which finding of females is impeded

Types of formulations

a. Reservoir-Type Dispensers

b. Microencapsulated dispensers

c. Female – equivalent dispensers

d. Wax emulsion formulations

e. Aerosol dispensers

Mating disruption in different insects

a. Pink bollworm: (Z, Z)- and (Z, E)- 7,11-hexadecadienyl acetates

b. Gypsy moth: (Z)-7, 8- epoxy-2-methyloctadecane (disparlure)

c. Codling moth: (E, E)-8,10-dodecadien1-ol (codlemone)

d. Tomato pinworm: (3E, 8Z, 11Z)-tetradecatrien-1-yl acetate and (3E, 8Z) -tetradecadien-1-yl acetate.

e. Citrus leaf miner: (Z, Z, E)-7, 11, 13-hexadecatrienal (Z7Z11E13- 16Ald), Z7Z11-16Ald, and (Z) 7-hexadecenal

f. Yellow stem borer: (Z)-11-hexadecenal and (Z)-9-hexadecemal.

CONCLUSION:

Mating disruption using synthetic sex pheromones is an effective and environmentally friendly way to help manage some insect pests. Pheromone-based mating disruption products do not kill anything, not even the target pest, but can provide economic control of some pest species while reducing pesticide use. Reducing the use of insecticides can have additional benefits for pesticide resistance management and for preservation of beneficial insects, mites and spiders. Mating disruption programs do have some limitations, as do all pest control programs, and may require some specialized monitoring to ensure their success. Mating disruption programs can be extremely useful parts of IPM programs and work best in large, contiguous areas.

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